Handbook of Interactive Computer Terminals

Duane E. Sharp

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The computer has become a very useful tool as the power of remote data communications has increased and the development of interactive devices has progressed. The capability of using the computer from a remote location to perform a variety of data processing operations has opened new horizons. These developments have involved the use of electronic technology and computer techniques leading to terminal designs with increasingly sophisticated capability.

The growing technology surrounding interactive computer terminals has produced a multitude of devices with a diversity of applications. The result is a complexity of choice for the user.

Duane Sharp's comprehensive handbook clearly describes the technologies of various elements of computer terminals. The author provides performance characteristics for simple terminals with and without displays, and for intelligent terminals. He gives evaluation guidelines for selecting terminals as well as specification pages on approximately 150 different models.

The book presents an analysis of various technologies in interactive terminals, including discussions of key-

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Dedicated to my family, Myrna, Heidi, Brett, and Dana

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PREFACE

The burgeoning technology surrounding interactive computer terminals has produced a multitude of devices with a diversity of applications and a consequent complexity of choice for the user.

It is fair to say that the computer has become a much more useful tool as the power of remote data communications has increased and the development of interactive devices has progressed. The capability of using a computer from a remote location to perform a variety of data processing operations has opened new horizons. All of these developments have involved the use of electronic technology and computer techniques to arrive at terminal designs with an increasingly sophisticated capability.

In addition to the refinement of basic terminal performance characteristics to provide additional data communications features, the concept of programmability has been one of the key attributes of the most recent developments in terminal technology. The aim of programmability is to make the terminal more self-sufficient, enabling it to pre-process data prior to that data being transmitted to a host computer.

This handbook presents a detailed analysis of interactive terminals: the technology used, performance characteristics, and some guidelines for evaluating pertinent characteristics for these applications. Evaluation guidelines include an extensive series of specification pages for interactive terminals offered by manufacturers. All models for which information could be obtained have been included.

Providing this information has involved compilation of manufacturer's information, research, and discussion with users. This task would have been even more formidable without the cooperation of the many suppliers whose products are presented in this handbook. To all suppliers who have contributed, the author expresses appreciation.

The author also wishes to acknowledge the valuable contribution of Glen Farrell, a long-time colleague with considerable data-processing experience, for the information on evaluating intelligent terminals, and other advice and counsel.

It is appropriate that the author extend special acknowledgement to the Communications Research Centre (CRC) of the Federal Department

of Communications in Ottawa, Ontario, Canada. Besides the specific references in this handbook, CRC research reports on interactive terminals have provided much of the background material for this handbook.

Duane E. Sharp, P.Eng.

PART I

Technology and Performance

INTRODUCTION TO DATA COMMUNICATIONS AND INTERACTIVE COMPUTER TERMINALS

1

It has been estimated that in the year 1980 computers in the United States alone will transmit or receive 250 *billion* data transactions over telecommunication lines. Interactive computer terminals will play a major role in this communications volume.[1]

Communicating effectively with computers has been a challenge to man ever since the computer was invented. Early computers used simple keyboard-to-printer terminals as *consoles* which allowed an operator to control computer operation and to perform functions such as monitoring program run times, doing housekeeping operations, and running diagnostic routines. The computer console was the earliest man/computer interactive device—the forerunner of today's sophisticated terminal technology. Figure 1-1 illustrates a data communications network, showing the various elements which make up a typical teleprocessing system.

Teleprocessing is one of the most rapidly growing areas in the application of data processing for the improvement of business efficiency. In the future, the power and versatility offered by interlinking terminals and computers will be felt in diverse areas, in industry, in our homes, and literally throughout society.

These reflections of our expanding technology undoubtedly will change our lives as a new type of interaction with computers develops. The human user will interact with the tremendous logic power of the computer and its vast stores of data; an interaction which will yield results that neither man nor computer alone could achieve.

Networks of telecommunications facilities are expanding at an in-

[1]James Martin. *Introduction to Teleprocessing.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972, p. 2.

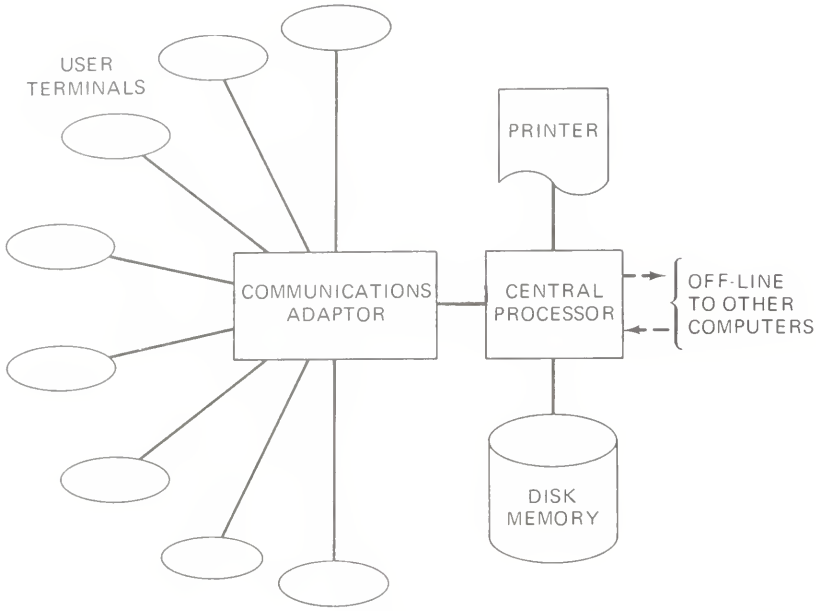


Figure 1–1. Typical data communications network. (Courtesy, Datashare Corporation, San Antonio, Texas.)

creasing rate. New equipment enables these networks to use data communications more efficiently and more economically than ever before. Computers are able to "dial up" other computers, terminals can communicate with each other, and information is transmitted at high data rates between machines and from user to machine.

The numerous applications of data communications have resulted in an estimated 4 to 5 million computer terminals being used in teleprocessing networks. Continuing development of new communication facilities, both networks and hardware, will expand the whole field of data communications, and will become the major aspect in meeting the challenge of efficient business communication.

Offices, factories, and even homes will use data communications equipment and networks to access computers at locations remote from the computing system. There will be many tasks which will be performed by this combination of technology, and large data banks will be capable of access, interrogation, and response.

Information placed in computer storage may be transmitted immediately to the computer from a terminal or it may be stored for later transmission. Data can be prepared on-line or off-line and may be punched out on a paper tape, or prepared in some other form, prior to transmission to a computer.

Data transmission costs will continue to decrease as more efficient use

is made of technology. Recent years have seen a virtual explosion in areas related to interactive computer terminals, a key element in improving the efficiency and economy of accessing a host computer.

One view of an interactive terminal as an interface between an application (*task environment*) and remote data processing and storage resources is shown in Figure 1-2. This graphic representation of a terminal relates input and output modes, the active elements in a terminal which control input and output operation, and the processing features of a remote computer. Input may be data or instructions, and the computer can respond with either data or instructional output.

1.1 INTERACTIVE TERMINALS

A wide variety of different devices can be used to communicate with a computer. Some are devices into which data are entered by human operators, while others collect data automatically. Terminals that allow an operator to have two-way communication with a computer, to *interact* with a program, are referred to as *interactive terminals.* This communication may be at a relatively low or high level of sophistication. For example, a terminal which accepts a credit card and provides a simple verification message is at the low end of the interactive spectrum. On the other hand, a terminal which provides the facility for a user to perform a number of editing, formatting, and preprocessing functions is defined as having a degree of *intelligence.* In Chapter 4, an intelligent terminal is defined as one which is capable of being *programmed* by the user, a definition of intelligent terminals which is used throughout this handbook.

Most interactive terminals consist of a keyboard and printer or a keyboard and some type of display. Figure 1-3 is a pictorial representation of the various components and functions of the peripheral devices in a typical interactive terminal, showing both input and output operations. Some interactive terminals can be used for off-line data preparation, or as elements of a cluster of manual-input devices in a data collection system. Options to enhance the capabilities of interactive terminals include tape cassettes and cartridges, small disks, logic circuitry, and additional core memory. Microprogramming and stored-program minicomputers also are incorporated in some terminals.

Included in the definition of interactive terminals are both simple keyboards (with and without displays) and sophisticated intelligent terminals capable of performing front-end preprocessing of data and of being programmed by the user. The extent of coverage of the different technologies in Chapter 2 is directly related to the current level of interest in the user marketplace. Some devices have been used for a number

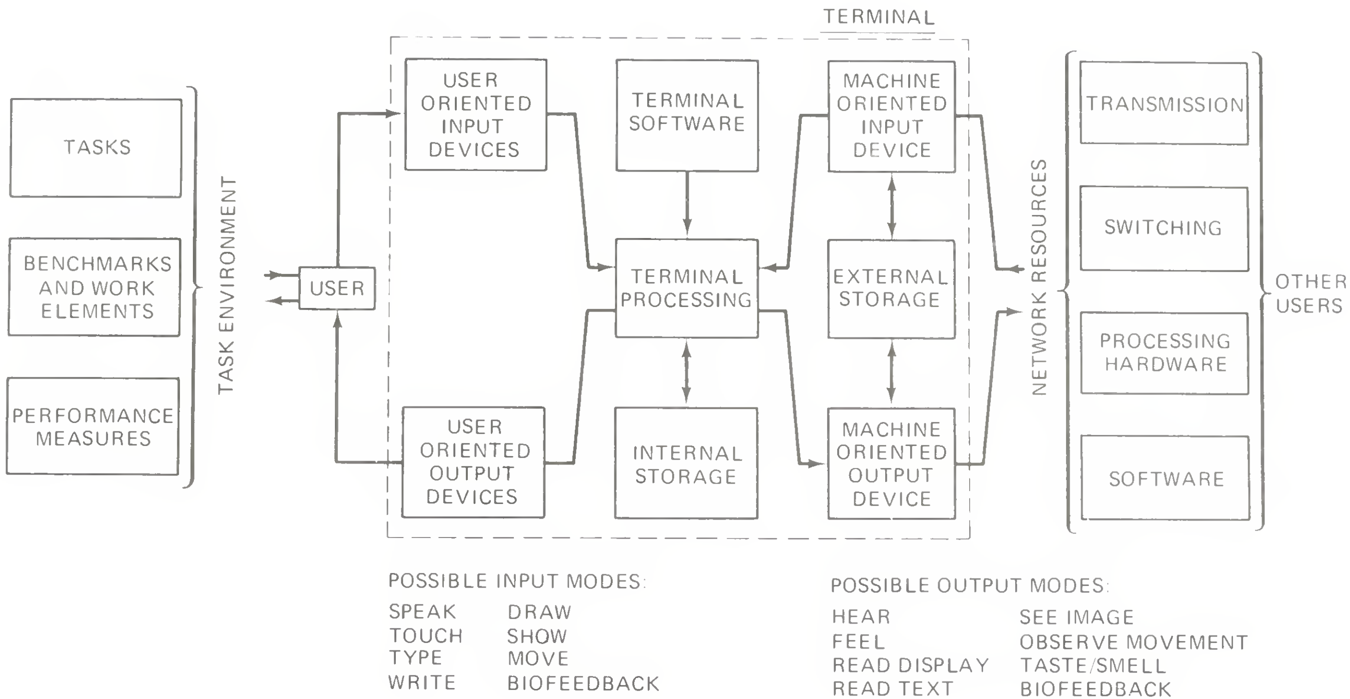


Figure 1–2. An interactive computer terminal as it interfaces a task environment to remote data processing and storage resources. (Source: CRC Report No. 1276–2, "Data Terminal Technology—Present and Future. Vol. II, Technology Forecasting and Assessment." Communications Research Centre, Department of Communications, Ottawa, Ontario, April, 1975.)

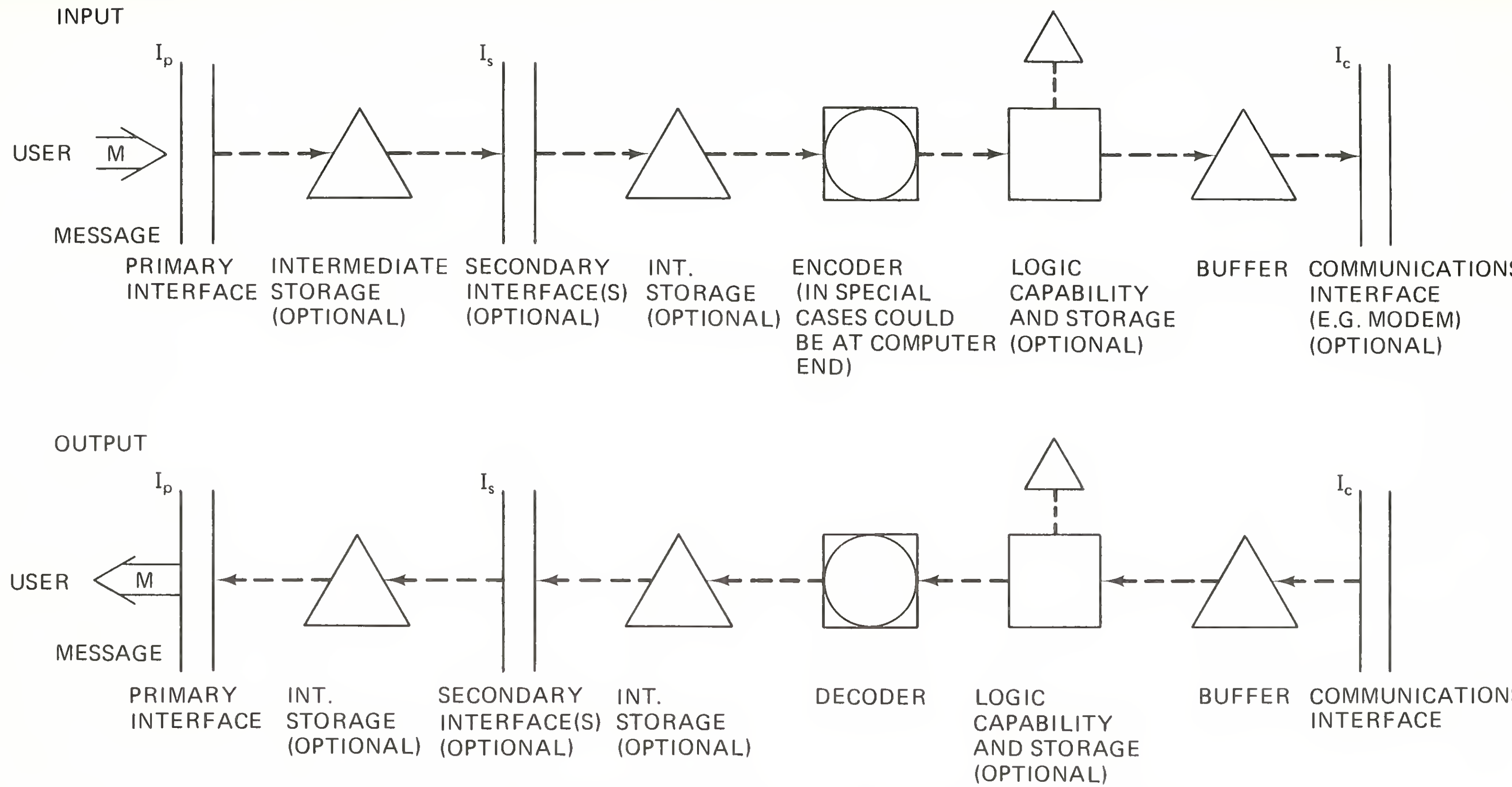


Figure 1–3. Functional representation of an interactive terminal. (Source: CRC Report No. 1276–2, "Data Terminal Technology—Present and Future. Vol. II, Technology Forecasting and Assessment." Communications Research Centre, Department of Communications, Ottawa, Ontario, April, 1975.)

of years, others are in the early stages of development, and some are just appearing on the market.

The cathode ray tube (CRT), the most commonly used display device, added a new dimension to terminal technology. Little did Heinrich Geissler realize when he first placed electrodes in a glass tube filled with gas to produce pretty colors that his *cathode rays* would form the basis for a modern-day device which would revolutionize data communications. The CRT is the display device used in most display terminals, although other technologies discussed in this handbook are gaining acceptance rapidly.

As previously noted, an interactive terminal is one which enables an operator to interact with the computer; that is, to provide input to and receive output from the computer. This handbook describes interactive terminals where both input and output capabilities are provided, and does not discuss *limited* interactive devices such as card-reading or optical character recognition (OCR) devices.

In succeeding chapters, evaluation characteristics are provided to enable users to evaluate terminals for various data communication requirements and to select suitable devices to meet specified performance criteria.

In the following paragraphs, terminals are briefly categorized and described according to general physical and functional characteristics. These characteristics indicate how data are input into the terminal and the form of the output. In subsequent chapters, details of the technologies used for each terminal category are examined. This input may be data or instructions, and the computer can respond with either data or instructional output.

1.1.1 Keyboard with Printer

The standard teletypewriter device is the best example of this type of terminal. It finds its greatest application as a simple terminal in the interactive time-sharing environment, and has been in use for a number of years. The capability of producing "hard (printed) copy" makes this terminal type distinct from others which use display devices as an output medium, and offer hard copy as an option.

1.1.2 Keyboard with Display

This is one of the most common types of simple interactive terminals because of its intrinsic capability to enhance user/machine communications. It usually incorporates an alphanumeric keyboard with some form of electronic display, but provides no hard copy to the user, except as an

option. Alphanumeric and graphic displays are included in this classification as the technology used is similar. These units are employed in a wide variety of data processing applications, and are used in almost all intelligent terminals.

Graphic Entry

The primary characteristic of this keyboard with display type is the use of a coordinate reference to initiate an enquiry, in addition to keyboard input. This class includes terminals which use light pens, a finger touch, or input drawn on a tablet with either hard or soft copy display for response. These terminals are used extensively in design applications to display three-dimensional shapes, and enable a designer to rotate, modify, and otherwise manipulate design characteristics.

1.1.3 Keyboard with Printer-Plotter

This classification is a variation of the keyboard with printer where printing capability is not limited to normal type, but may include hard copy, graphic display, diagrams, and other forms of printed material. The printer-plotter is generally a refined version of one of a limited number of printer technologies incorporating an optional plotting capability using ink and a plotting device driven by keyboard input.

1.2 APPLICATIONS OF INTERACTIVE TERMINALS

1.2.1 Basic Applications

There are an increasing number of applications of interactive systems. Some of these applications fall into the category of exchanging information, for example, information acquisition and retrieval, editing, and instruction.

Information Acquisition and Retrieval. This involves entering data into a computer using interactive methods to check the data on entry, an immediate error feedback, and the use of a host computer to provide explicit information. Redundant transcription and transmission of data is reduced by using this technique. Retrieval concerns the recovery of stored information using conversational techniques to ensure that all requested information is identified, and that the user has access to it. Retrieval and data entry are often cofunctions, since originators of information may have to ask questions before deciding what to enter into stored files. Library cataloging is one specific application area for information acquisition and retrieval. (See Figure 1-4.)

Editing. This is the storing of textual material to enable an opera-

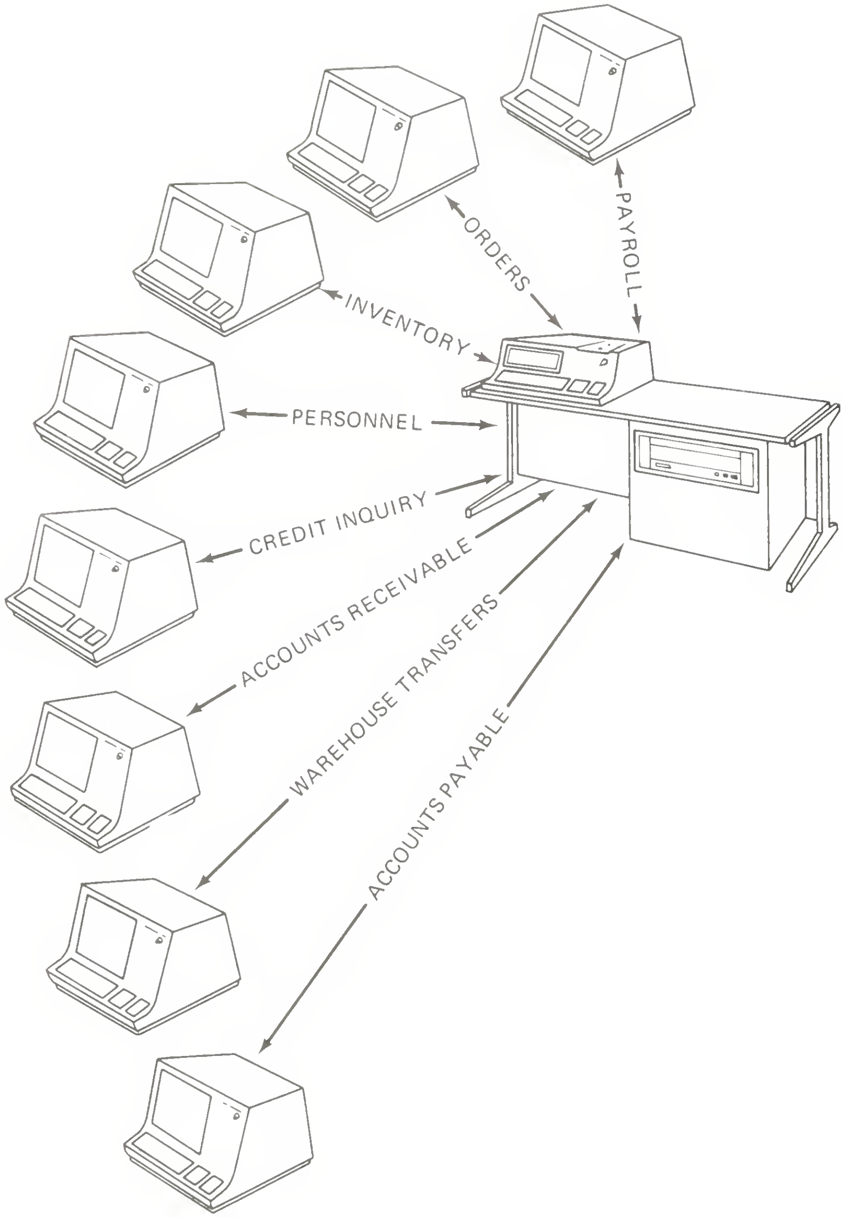


Figure 1–4. Some typical business applications of a multi-user, multi-task data communications system. (Courtesy, Datapoint Corp.)

tor (who may be the author) to prepare it for publication using an interactive terminal. Most of this activity consists of entering information in the same manner as typing it out on a typewriter, and then allowing the author to make changes—adding or deleting material, and moving portions of it around. This application also extends to the editing of highly structured material.

Instruction. This involves using the fundamentals of the instructional process which essentially consist of asking a student questions, knowing the answers, and then comparing the responses with the known answers. In instructional systems, we usually have a situation where the system asks users to confirm existing information, and the system response differs according to whether the user can or cannot provide the correct response.

1.2.2 Higher Level Applications

At a higher level than the three basic application areas are those which represent a much closer user/machine integration than the basic application. These applications may produce a directly usable product, for example, a computer program or an electronic circuit diagram. They may be instrumental in a decision-making process whether in a business or a military environment.

One of these applications is where computer programmers use the user/machine communication capabilities of an interactive computing system to produce computer programs. This application offers considerable benefits in the programming area, including a "natural" creative facility, providing instant feedback, rapid modification, and the storage and computation power of a host computer.

The *design process* is another creative area where interaction between user and computer can create an information structure, or a model which often represents a relationship that is not easy to express using other techniques. The computer provides valuable assistance in evolving the design, and often can be used to develop the product. Using a computer to design a textile fabric is quite similar to designing a building or an electronic circuit. In all of these examples, the power of the computer is used to help the designer examine alternative designs quickly and with absolute accuracy where calculations must be performed.

In a *decision-making* application, for instance, where a decision is made by a military commander or a business or government executive, it is rarely a straightforward choice—there is as much design in a plan or a strategy as there is in a selection of well-defined alternatives. Interactive systems do not make the decisions, however, in the decision-making process. They only assist by supplying information and occasionally pointing out what has to be done to reach a decision. Computer decision-making is limited to situations where variables are relatively few and well-defined. Generally, management decisions involve many loosely-defined variables. Since computer programs cannot draw inferences, a characteristic of human intelligence, nor produce original ideas, command and management systems use a combination of information retrieval and simulation.

1.2.3 User-Machine Communication

Communication between people and machines requires the capability both to interpret and react to each other in a common language and using basic elements of user-machine communication. This is accomplished by using appropriate communication elements, some of which are described in the following text.

Hardware. This involves transducers or other methods of transforming "signals" in both directions between people and computers. Interactive terminals are a key element in user-machine dialogue.

Programming. A computer requires a program to perform its role in a conversation with a user. Programming is done by a user in the form of a list of instructions which the machine will execute. With this in mind, the real burden of effective user-machine communication is a human responsibility.

Language. Designers of user-machine communications systems have come to realize that a natural language provides the best medium for conversation in an interactive environment. Simplifying the act of communication and requiring less formal operator/user training is becoming extremely important. There is a large and growing world of specialists who are striving for improved computer interpretation of natural language, and further refining of user-machine communications.

1.2.4 Interactive Systems—Utilities of the Future

The versatility and capability of the computer will undoubtedly spread into every walk of life, affecting society in both work and leisure. Interactive systems will play a significant role in bringing the computer into our homes and offices until it becomes as commonly accepted as the telephone. Already, in many business operations, the computer is firmly entrenched as a necessary tool for conducting day-to-day activities. The limit to its applications are only those of human ingenuity and imagination. As William Orr has suggested, " . . . there is really only one 'application' of conversational computers, and that is whatever you do during the course of a normal working day."[2]

1.2.5 Using this Handbook

This handbook is designed to provide the reader with a detailed description of the technologies used in interactive terminal design, to describe

[2]Charles T. Meadow. *Man-Machine Communication.* New York: John Wiley & Sons, Inc., 1970, p. 11.

important performance characteristics of both simple and intelligent terminals, and then to relate these characteristics to evaluation guidelines. Chapters 5 and 6 illustrate these guidelines through standard specification pages for well over 150 interactive terminals of all types. Finally, the status of standards and protocols for interactive terminals is discussed in Chapter 7.

GENERAL CHARACTERISTICS OF INTERACTIVE TERMINALS

2

2.1 SEPARATING TERMINALS INTO MODULES

The classes of terminals described in Chapter 1 are composed of elements or *modules* as illustrated in Figure 2-1. Each module is functional and represents the operating characteristics of a typical interactive terminal. Specific subassemblies which perform these functions in the various classes of terminals are described in detail in this chapter.

There are six major categories of functional subassemblies which will be considered in this handbook. They are listed below with their primary functions.

keyboard—input

logic circuitry—local computations and data manipulation

memory—storage

printer—hard copy

display—soft copy

data transmission—communications

A number of different technologies are available from manufacturers of terminal equipment to perform the functional requirements of each module shown in Figure 2-1. Most of these technologies are currently available to the user market, although a few are still in various stages of development.

2.1.1 Keyboard

Keyboard input is a standard input mode in most terminals because of its versatility and capability of meeting input requirements in many applica-

very rapidly before making final contact) and number of operations (lifetime). Actuating a keyswitch generally does not make an instantaneous solid switch closure. The switch may open and close several times before final closure occurs. The *bounce time* is relatively short, in the range of 1 or 2 milliseconds. On a logic circuit timescale, however, it is several switch actuations. Figure 2-2 illustrates a number of typical switch configurations.

There are some switch technologies which do not exhibit contact bounce. These devices can be used without additional circuitry. Devices with contact bounce may require additional circuitry to filter out the bounce.

Individual keyswitch lifetime is typically in the order of 10^7 to 10^8 operations. This lifetime, however, does not necessarily relate to the failure rate of the complete keyboard. The conclusions reached in some failure studies indicate that with "average" usage (a 40-hour week was used as a typical work period) the most frequently used keyswitch, rated at 5×10^7 cycles, would fail in approximately two years. The most commonly used keyswitches are the space bar and the vowels a, e, i, and o. Semiconductor manufacturers have developed keyboard encodes which connect a keyswitch input into a unique code which a computer or terminal will recognize. This method permits use of single contact switches rather than multipole units. Most of the keyboard encoders in terminal equipment are MOS ROMs, which generate codes as well as eliminating the effects of contact bounce, *n*-key rollover or lockout, and multilevel encoding.

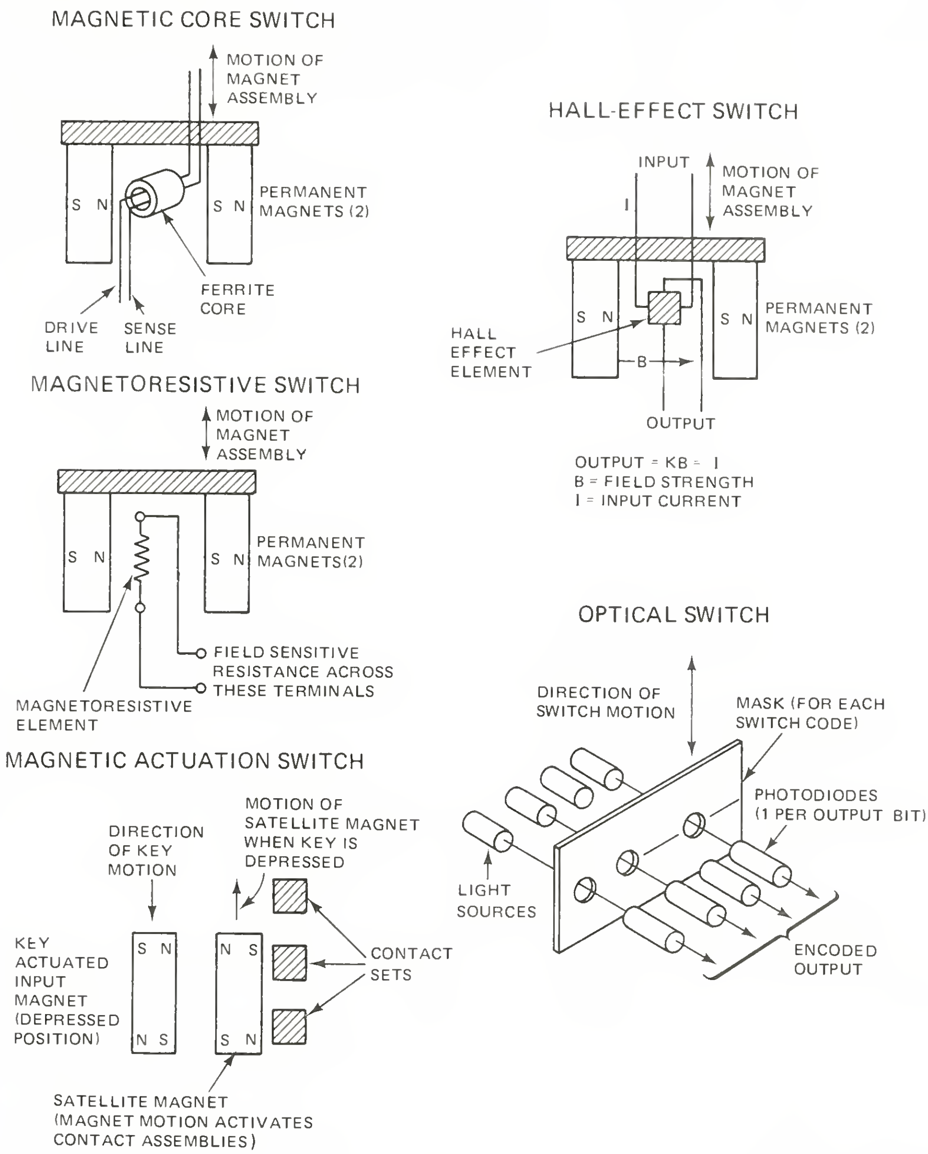
Rollover describes the correct encoding of data for all depressed keys. It is most useful in *burst-typing* applications where rapid entry of data is necessary, for example, in word processing.

Lockout blocks data from every key except one, until the selected key is released. Accounting applications require this feature, since it ensures that erroneous numerical data will not be entered.

There are terminal keyboards with up to four levels of coding for each keyswitch. A manufacturer can supply more than four codes for a given number of keyswitches, however, this may result in decreased operator efficiency. Most keyboards consist of a single *printed circuit board* (PCB) with keyswitches and encoder mounted on it. In the following paragraphs, a number of different types of switches and their operating characteristics are described.

Mechanical

1. Dry Contact. This switch is the most commonly used in interactive terminals and consists of a simple mechanical contact of metal conductors. It is one of the lowest cost keyboards, but also has a relatively low oper-



typewriters. The design involves a mechanical matrix using the complete keyboard, which provides eight separate possible contact closures with a unique combination for each key. Before the introduction of solid-state encoders, this electromechanical design was a popular technique. It is, however, unreliable and will probably be more costly in the future than solid-state types.

3. Flexible Layer. In this switch design a flexible conducting metal disc contacts a rigid conductor pad on actuation of the keyswitch. The two conductors normally are separated by an insulating washer. This type of switch has a typical lifetime of 3×10^7 operations. One of its main features is a low physical profile.

4. Snap-Action Disc. A small cup-shaped metal disc is pressed flat

when a key is actuated to form a conducting path between two conductors. This switch element has a lifetime of approximately 10^7 operations.

Electrical

5. Capacitance. A change in the capacitive coupling between two metal plates is translated into a switching action. Since this type of switch often is fabricated without moving parts, it has a high lifetime (typically 10^8 operations).

6. Reed. This mechanism uses two cantilevered magnetic reeds encapsulated in a sealed glass tube. The reeds are actuated by a permanent magnet attached to the key. Typical contact rating for this switch is 10^8 operations.

7. Hall-Effect. In this type of switch, an output voltage is developed in a semiconductor device which is proportional to the surrounding magnetic field strength. This is known as the Hall-Effect. The magnetic field can be varied by a permanent magnet attached to the key. Reliability is extremely high (typically greater than 10^8 operations), however, these devices are also one of the most expensive types of keyboard switching.

8. Magnetic Core. The magnetic core device uses two sets of windings on a ferrite core which act as a transformer. The frequency of an oscillator connected to the primary winding and coupled to the secondary winding is varied by moving a magnet attached to the key. The device requires an amplifier on the secondary circuit to produce a positive switching action. Since no mechanical switch contact is used, reliability is high (5×10^7 operations).

9. Magnetic Repulsion. There are two magnets used in this switch device. One, a floating magnet, is attached to an electrical conductor. A second magnet is attached to the key. Actuating the key magnet moves it closer to the floating magnet. Like poles on the two magnets cause a repulsive force to move the floating magnet and associated conductor. The conductor contacts a second conductor producing a switch closure. The use of mechanical contacts limits switch lifetime to 10^7 operations (typically).

10. LED/Phototransistor. Light from a *light-emitting diode* (LED) is directed toward a phototransistor. Actuating a key moves a mask out of the path of the light, permitting the light to act on the phototransistor, which conducts current when exposed to light. This current produces a switching action. These switches have a very high lifetime of approximately 10^8 operations.

11. Conductive Elastomer. An actuating plunger is used in this device, with a flexible conductive material on its end. Silicone or some such flexible organic compound, impregnated with carbon, silver, or gold particles is used as a conductive element. When the key is actuated, the

conductive elastomer contacts and compresses against two conductors. Projected potential cost of a "sheet type" conductive elastomer keyboard is approximately 25 percent of that of a dry contact switch, and its lifetime is rated at about 10^8 operations.

2.1.2 Logic Circuitry

The history of the development of *logic circuitry* dates back to vacuum tube logic circuits of early computers, which were rapidly replaced by the transistor in the late 1940s. Integrated circuits (IC), which contained several circuits on a single chip, appeared in the 1960s, and were followed by *large scale integrated* (LSI) circuits with several hundred transistors on a single chip. The latter technology is used extensively in interactive terminals and has been a significant contribution to the improved performance characteristics of these devices in recent years.

As logic circuitry became more compact, and the functional capability of circuits on a chip of semiconductor material increased exponentially, two primary technologies emerged from the developmental stages to become widely used in LSI—*bipolar* and *metal-oxide-semiconductor* (MOS). The bipolar technique is based on the interaction of two types of charge carriers in the semiconductor material—holes and electrons. The MOS field effect transistor (FET) is a unipolar device which operates on only one type of charge carrier.

Concentration in the first decade of transistor development was mainly on bipolar transistor technology. The greatest advances in the last decade, however, have been made in MOS LSI circuits. The following paragraphs discuss the characteristics and logic functions of both types of circuits.

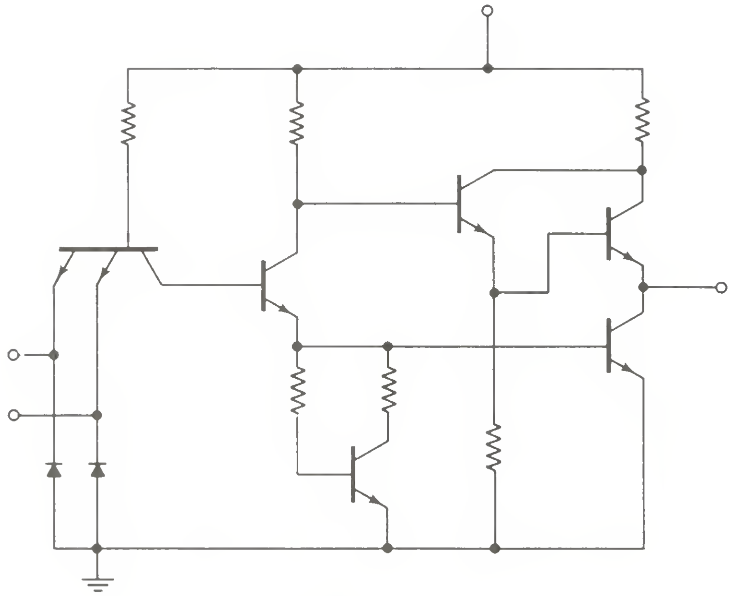
1. Bipolar Technology

Bipolar transistors are normally faster than MOS transistors because of their physical design. Some MOS device speeds, however, approach those of bipolar devices. Bipolar logic circuits (see Figure 2-3) can be categorized into subsets, as shown below:

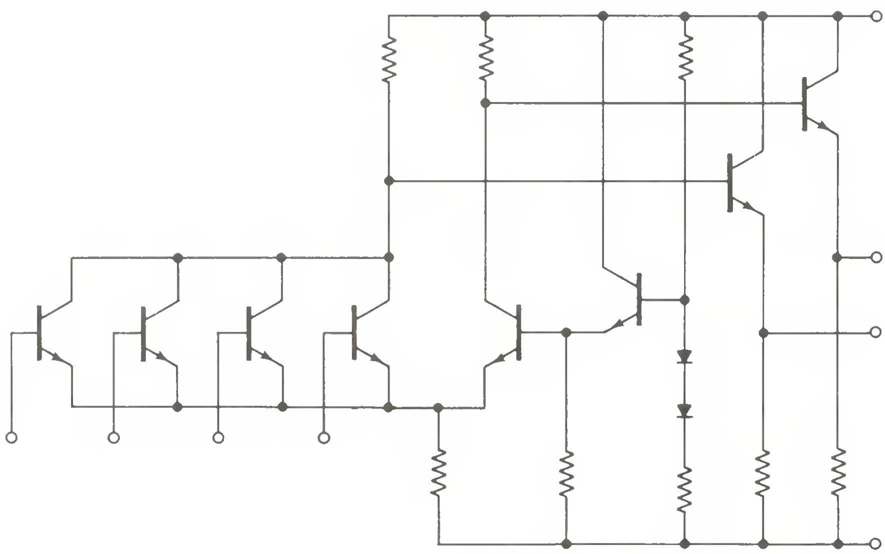
Saturating → transistor-transistor logic (TTL)
→ diode-transistor logic (DTL)

Nonsaturating → emitter-coupled logic (ECL)

In operation, a saturating transistor has an excess charge buildup in the base region which must be discharged before the transistor can be turned



TYPICAL TTL GATE



TYPICAL ECL GATE

Figure 2–3. TTL and ECL bipolar logic circuitry. (Courtesy, Department of Communications, Ottawa, Ontario, Canada.)

off. This may take a relatively long time, in terms of logic operation, which is measured in nanoseconds (10^{-9} seconds).

TTL is the most widely used of the bipolar saturating type transistors because of its wide range of applications and its relatively low cost.

Schottky TTL logic is one of the circuit variations in the TTL family. It can operate at speeds close to the nonsaturating ECL type and is easier to fabricate.

A nonsaturating transistor (IC circuit) has higher speeds than the saturating type because it does not have the excessive charge buildup which is characteristic of the latter.

2. Metal-Oxide-Semiconductor (MOS)

There are several distinct MOS families. These families are derived from two basic types of MOS transistors—*depletion* and *enhancement*. Applying a signal voltage to the gate of a depletion transistor turns the transistor off. In the enhancement transistor or IC device, the operation is complementary to the depletion device. Current flow in the transistor increases, turning the transistor on when a signal voltage is applied to the control gate. A further separation depends on whether current flow is due to electrons (n-channel) or holes (p-channel). Electron mobility is greater than hole mobility, therefore n-channel devices are inherently faster than p-channel devices. MOS logic circuits used p-channel technology, because it was easier to manufacture. However, n-channel devices have recently been produced in larger quantities as manufacturers resolved production problems. N-channel and p-channel logic circuits are not used in *small scale integrated* (SSI) circuits, as is bipolar logic. The main advantages of MOS are: high packing density and low power requirements. In LSI circuits where a large number of gates are required, MOS technology is used for *microprocessors* and *programmed logic arrays* (PLA). Interactive data terminals use this technology extensively. Terminal manufacturers can achieve considerable reduction in assembly cost, as well as in physical size, by employing MOS LSI logic chips (see Figure 2-4).

Complementary-Symmetry MOS (CMOS). In CMOS, both n-channel and p-channel circuits are used. One transistor forms the load for its complement transistor, and one transistor is turned on while the other is turned off. The high off impedance of MOS transistors means that load current is extremely low, except during switching. Complementary bipolar logic is possible to produce, but only with discrete transistors. At present, manufacturing processes have not been developed which allow the fabrication of complementary bipolar transistors on the same substrate. The much lower power requirements for CMOS logic, however, will encourage further development of this technology.

Metal-Nitride-Oxide (MNOS). The MNOS semiconductor is another MOS development. Memory circuits are the main application of this technology. Storage capability and electrical field alterability are two characteristics of these devices. At present, no family of MNOS logic circuits is commercially available. Essentially, MNOS uses a p-channel MOS

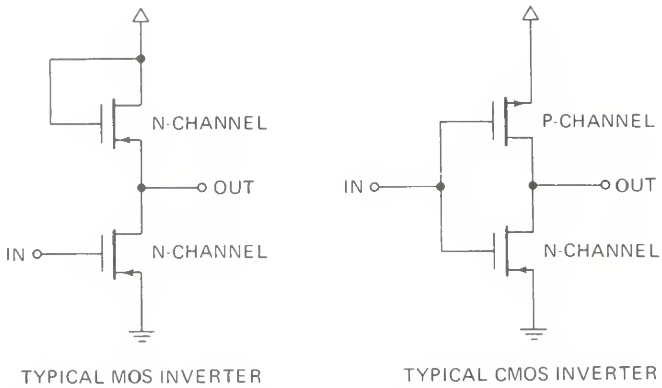


Figure 2–4. MOS and CMOS logic circuitry. (Courtesy Department of Communications, Ottawa, Ontario, Canada.)

structure with the gate insulator composed of a thick layer of silicon nitride and a thin layer of silicon dioxide.

The *silicon-on-sapphire* (SOS) method involves growing a silicon wafer on a sapphire substrate. Sapphire is a better insulator than conventional silicon dioxide, therefore interdevice spacing is reduced and packing density can be higher.

Comparison of Semiconductor Logic Circuits. Table 2-1 compares several performance parameters of each type of circuit using relative performance characteristics. Grading is from 1 (best) to 6 (worst) and, in the case of more than one family with relatively equal performance, equal grading is shown. As an example, a "1" rating means the *highest* packing density, while the same rating in cost/gate means the *lowest*. With constant development in semiconductor technology, performance ratings may change with time.

TABLE 2-1. Semiconductor Logic Comparison*

PARAMETER	ECL	BIPOLAR SCHOTTKY TTL	TTL	MOS CMOS
Propagation Delay	1	2	3	4
Power Consumption	4	3	2	1
Packing Density	2	2	2	1
Cost/Gate	3	2	1	2

*CRC Report No. 1276-1, "Data Terminal Technology—Present and Future Vol. I—State-of-the-Art." Communications Research Centre, Department of Communications, Ottawa, Ontario, April, 1975.

2.1.3 Memory

Simple interactive data terminals do not require an internal memory, since data is transmitted or received at low data rates which the terminal and operator can accept. There are advantages to transmitting data at higher speeds, however, and to accomplish this, buffer storage in the terminal is required. The major types of memory devices used as buffer storage in interactive terminals and the subcategories of each, are:

1. Magnetic disk or drum
   flexible disk
   rigid disk or drum
2. Magnetic tape
   tape cassette
   tape cartridge
   "IBM-compatible"
3. Ferrite core
4. Semiconductor
   bipolar
   MOS

The types listed above are the major categories in the present state-of-the-art of terminal memories. Others are under development and will undoubtedly appear as technology permits their cost-effective incorporation in interactive devices.

The IBM-compatible magnetic tape memory and rigid disk or drum can generally be justified only for applications requiring large memory capacity. Frequently, they are used with batch entry data terminals, but seldom with interactive terminals.

Two Main Divisions

The two major functional divisions in terminal buffer memories are *read/write* and *read-only*. All of the major types in the previous list have both read and write capabilities. *Read-only memories* (ROM) can be a limited subset of any of these major types.

Read/write memories are used as buffer or *scratch-pad* memories to store data temporarily. The prime function of a read/write buffer is to interface slow human operating speeds with fast (nanosecond) operating speeds of the data terminal and computer.

Read-only memories are used to perform a number of specific tasks,

including character generation, keyboard encoding, and code conversion. In intelligent terminals they frequently are used for table lookup and microprogramming.

Magnetic Tape

This memory type consists of a thin layer of material, such as iron oxide or nickel cobalt, which possesses magnetic properties. The material is deposited on an acetate or mylar film. In the write operation, the magnetic tape is passed through a magnetic field produced in a recording head, and iron oxide particles are permanently polarized according to the direction of the magnetic field, which is representative of the data "written" on the tape. The magnetic field is produced by a drive current in a coil wound around a U-shaped core.

During the read operation, the tape is again passed under the recording head, and the magnetic field which has been established with the iron oxide reproduces the data which was induced in it during the write operation. Magnetic tape memory finds its best application where large amounts of data are to be stored. While an IBM-compatible magnetic tape memory is capable of storing 10^7 bits or greater it has a relatively long access time. For an interactive terminal the large storage capacity normally is not required. Tape cassettes or cartridges offer low-cost storage for terminal applications, and use the same magnetic storage principles as the larger magnetic tape devices.

The Philips tape cassette unit is widely used in home entertainment audio equipment, and has been accepted as the standard in the tape cassette storage field. Both cassette and cartridge have similar advantages in low cost ($700–$1200), small packaging for ease of handling, and sufficient storage for most interactive data needs (typically 10^6 bits). There is little difference between cartridge and cassette in terms of performance, although the tape cassette has found wider user acceptance.

Magnetic Disk or Drum

Both of these memory types use the magnetic field principle, and employ microscopic particles of materials with magnetic characteristics. Magnetic particles are bonded to the surface of a drum or disk in this technology, which makes the device a short magnetic tape. Although total bit storage capacity of the drum or disk is almost the same as magnetic tape (typically 10^5 to 10^6 bits), the average access time for disk and drum is much faster. Fixed disk or drum storage is relatively costly and, therefore, rarely used in interactive terminals.

The flexible or *floppy* disk is cost-competitive with cassette or cartridge memory and is rapidly displacing cassette and cartridge memory

in many applications. The floppy disk is a thin, flexible, magnetic disk capable of storing over 1 million characters of data.

Semiconductor

Developments in monolithic semiconductor technology or large scale integration (LSI) have brought increasing chip density and higher reliability. Continual reduction of per bit costs for stored digital data, combined with the above characteristics, have made semiconductor memories cost-competitive with core memories in smaller (less than 64 K of storage) systems. The advantages of semiconductor memories over other types are:

- compatibility with logic circuitry
- a single memory chip contains the electronics for addressing and decoding
- high speed

Semiconductor memories are volatile; that is, data are normally lost whenever there is a power failure, and standby power sources must be used in critical applications to prevent any loss from occurring.

All semiconductor memories operate in a similar manner. A matrix of memory cells (Figure 2-5) is arranged with "X" and "Y" address decoders so that a specific memory cell may be addressed.

During a write operation, a data bit is transferred to a particular memory cell, and during a read operation, the data bit is transferred from the addressed cell. Read-only memories (ROM) record permanent data in each memory cell. No write circuitry is provided in these memory types. Programmable read-only memory (PROM), another form of ROM, allows data to be altered or reprogrammed, but this type normally is used as a ROM. PROM devices frequently are employed in the preproduction stages of terminal development to enable terminals to be programmed by

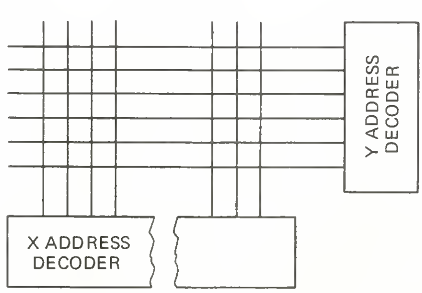


Figure 2–5. Memory matrix. (Courtesy, Department of Communications, Ottawa, Ontario, Canada.)

the manufacturer. Lower cost ROMs may be used after the design has been finalized.

ROMs often are employed as code converters in keyboard encoders or as conversion devices from the code employed in the computer to that used by the data transmission medium. ROMs also are used as character generators to create specific dots in a dot-matrix character or specific bars in a seven-segment character in display or printer units.

Random access memory (RAM) is used in interactive terminals where data must be written and then read at a later time. A refresh memory for a keyboard with display terminal and a memory buffer between terminal and data transmission medium are two areas where RAMs are used extensively. Shift registers and other serial access memories have been used as refresh memories in older keyboard/display terminals, but the improved cost/performance characteristics of RAM virtually have eliminated earlier technologies. Within the RAM memory types, there are two basic categories:

1. Bipolar memories which use standard transistor *flip-flops* to store data. They are faster than MOS memories, but are more expensive to manufacture and use more power. Bipolar memories are manufactured as either saturating TTL circuitry or as nonsaturating ECL. As discussed under Logic Circuitry (Section 2.1.2), ECL memories are inherently faster than TTL because of the nonsaturating operation.

2. Metal-oxide-semiconductor (MOS) field-effect memories—*p*- or *n*-channel—operating in either depletion or enhancement mode. As in logic circuitry, most MOS memories are *p*-channel devices. Static MOS memory cells use flip-flops as in bipolar memory circuits. Dynamic MOS memory cells use high impedance field-effect devices for data storage. The devices charge a capacitor to store data. Dynamic memory has the advantage of using a single transistor, and very high packing densities can be achieved. Because dynamic memory cells have a capacitive storage element, they require periodic recharging; however, when not being used in a read or write mode they consume very little power. A static memory is easier to use, but dissipates more power. Typical circuitry for both dynamic and static MOS memories is shown in Figures 2-6 and 2-7.

The major families of semiconductor memory circuits are shown in Table 2-2 with a relative comparison number for each performance category. The grading system is the same one used for the logic comparison in Table 2-1 (1 is the best; 6 the worst), and is based on latest available information. Although semiconductor memories, particularly *n*-channel

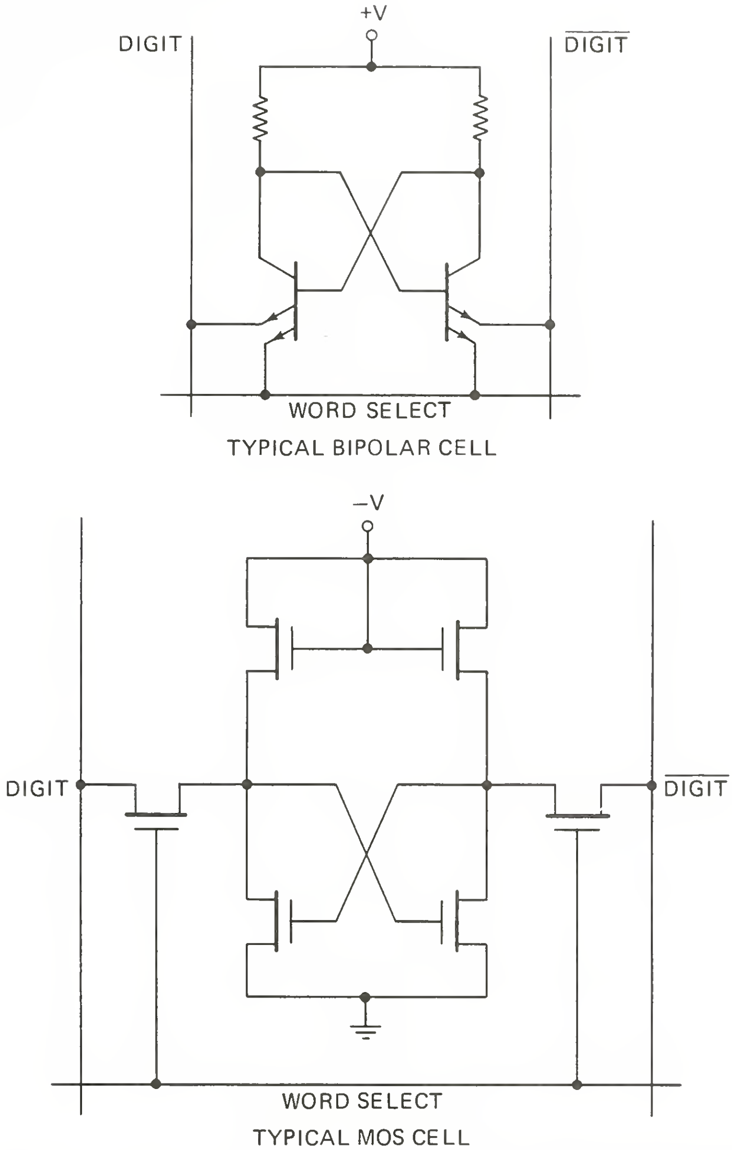


Figure 2–6. Static semiconductor memory cells. (Courtesy, Department of Communications, Ottawa, Ontario, Canada.)

types and complementary MOS, are still under development, manufacturers are continually reducing intercell spacings and cell size. Total material costs are decreasing, while yields are increasing, with the resulting trend toward decreasing costs of the total semiconductor memory package.

Ferrite Core Memory

Ferrite material with magnetic properties is used to produce circular ferrite core memories, long a standard technique in the computer industry. Powdered compounds of manganese, zinc, copper, or nickel are typ-

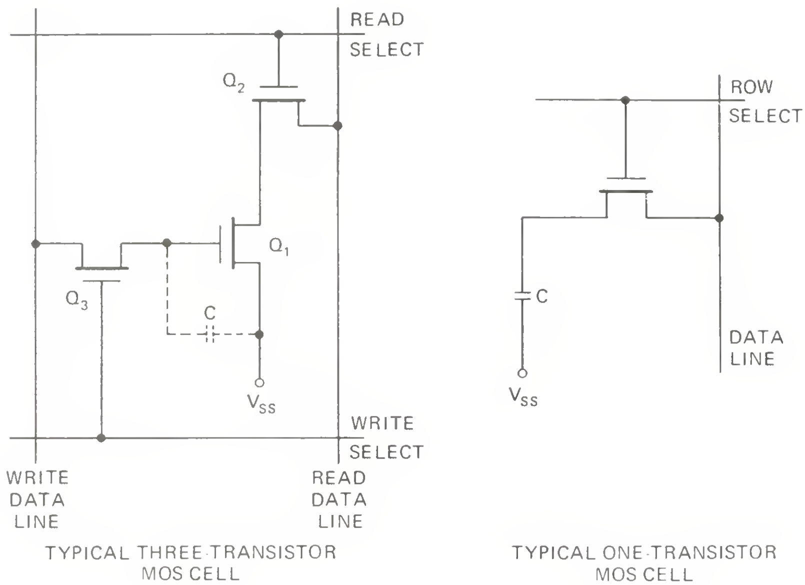


Figure 2–7. Dynamic semiconductor memory cells. (Courtesy, Department of Communications, Ottawa, Ontario, Canada.)

ical of the materials used. Current passing through a coil, wound on a ferrite core, magnetically polarizes the core according to the current direction. Cores are assembled in an X–Y matrix, similar to the matrix in a semiconductor memory. Individual cores are accessed by selecting specific X and Y lines. The major advantage of ferrite over most semiconductor memory types is that they are *nonvolatile*; they do not lose data when

TABLE 2-2. Semiconductor Memory Comparison*

PARAMETER	ECL	BIPOLAR SCHOTTKY TTL	TTL	MOS *N*-CHANNEL	MOS *P*-CHANNEL	CMOS
Access Time	1	2	3	4	5	6
Power Consumption	6	5	4	2	3	1
Packing Density	4	4	4	1	2	3
Cost/Bit	6	5	4	1	2	3

*CRC Report No. 1276-1, "Data Terminal Technology—Present and Future Vol. I—State-of-the-Art." Communications Research Centre, Department of Communications, Ottawa, Ontario, April, 1975.

power is removed. On the other hand, data bits stored in core are destroyed during the read cycle, and must be rewritten to be reproduced once they have been read.

2.1.4 Printer Subassemblies

There are two basic types of print mechanisms—*impact* and *non-impact.* Each of these basic types employs several different technologies to produce hard copy. Print mechanisms are compared in Table 2-3.

Impact Printers

In the following paragraphs, three of the most common impact printing methods are described. Most interactive terminals use impact printers in simple terminals without displays (see Chapter 3) and in optional printer peripherals used with display terminals, both simple and intelligent. Some terminals use non-impact printers, which are quiet and fast, and probably will be used more widely as the non-impact technology develops.

1. **Typewriter-style Print Wheel.** This print mechanism is usually designed around the following three elements:

a single character imposed on the end of each arm in a series of arms, similar to a conventional typewriter mechanism.

a type ball with the complete character set embossed on its surface, similar to the IBM Selectric® concept.

the entire character set embossed on a vertical drum, similar to a teletypewriter mechanism.

Selection of a desired character is accomplished using a variety of mechanical techniques. When a character has been selected, an inked ribbon is sandwiched between the print wheel and the paper, and the

TABLE 2-3. Comparison of Impact and Non-Impact Print Mechanisms.*

	IMPACT	NON-IMPACT
Produce Multiple Copies	Yes	No
Noise Level Characteristic	High	Low
Speed	Low	High
Requires Special Paper	No	Some
Reliability Characteristics	Moderate	High

*CRC Report No. 1276-I, "Data Terminal Technology—Present and Future Vol. I—State-of-the-Art." Communications Research Centre, Department of Communications, Ottawa, Ontario, April, 1975.

character is imprinted upon impact. Since an impact printer operates on serial data input only, it is limited to speeds of less than 30 characters per second. However, the unit is low-cost and enables character font to be changed easily.

2. Hammer-style Printer. The character set is embossed on a fixed wheel or chain in this type of mechanism. The desired character is selected and then a hammer strikes the back of the paper, forcing it against the selected character.

In higher speed printers, embossed characters are often fastened to a continuously moving chain, and use an individual hammer for each column of the page. When the desired character is aligned with the desired column, the hammer solenoid is actuated, and the character imprinted. This type of printer has a much higher printing speed, typically 200 to 1500 lines per minute for a 132-character per line output. The print wheel and chain type printer, however, are considerably more expensive than the typewriter-style unit.

3. Dot-Matrix Impact Printer. In this type, each character is composed of a dot matrix, usually 5×7 or 7×9. Matrices with more dots have more legible characters; however, this requires greater complexity at proportionately higher cost. A 5×7 dot-matrix printer, for example, uses five solenoid-actuated pins. These pins impact the paper at each character position. Seven "rows" of dots must be printed in order to form the complete character. This method of forming a character is similar to that used in dot-matrix displays, which are described in Section 2.1.5. Using multiple impacts to generate a single character increases wear and reduces printer lifetime, but this type of printer is relatively simple and, therefore, less expensive than the hammer-style printer. Graphics can be produced with a dot-matrix printer with reasonably good resolution, and nonstandard characters can be generated easily.

To achieve higher printing speeds in both hammer-style and dot-matrix printers, mechanical modifications are made in some equipment. Multiple character set wheels, chains, or multiple rows of dot-matrix pins may be used.

Non-Impact Printers

The following paragraphs describe the operation and characteristics of non-impact printers.

1. Electrostatic. Xerox® technology is the most common type of electrostatic printing. This technique uses a charged latent image of an entire page stored on a web or drum of semiconductor material for dry printing on ordinary paper. A toner-powder adheres to this charged image and is then transferred to the paper. Heating the paper fuses the toner to it and a permanent image is created. Line-by-line electrostatic printing also is used with paper coated with a nonconducting dielectric.

A dot-matrix is the most common technique for line printing. Most have a graphic capability, as well as being able to provide multiple copies and produce fixed-format overlays.

2. Electromagnetic. Line data is recorded on a magnetic tape loop which then picks up a magnetic toner. The toner is transferred to the paper and fused to it by a heating technique.

3. Thermal. This type of printing requires heat-sensitive paper, and usually employs a dot-matrix format with dots or pins similar to those in the dot-matrix impact printer. The dots or pins are heated by electrical pulses which turn the paper black where it has been heated to form the desired character.

4. Electrosensitive. A chemically-treated paper with minute iron particles is used for this type of printer. When exposed to an electric field, these particles become opaque. Facsimile transmission is the market area where this technique is most frequently used. A helix, mounted on a drum with paper sandwiched between it and a page-width bar, is the key element in this method. Varying electrical fields between helix and bar produces varying degrees of opacity (grey-scale) on the paper. This is a simple method, and provides full graphics capability. Resolution is limited, and normal print-size characters would be extremely difficult to produce.

Table 2-4 compares the different types of impact and non-impact printers.

2.1.5 Display Modules

In display technology, the cathode ray tube (CRT) is the most common device used, although other methods described in this chapter are beginning to appear on the market.

Interactive terminals with display capability employ a variety of techniques for displaying information. The following descriptions explain the operation of a range of *soft* displays, implying there is no hard paper copy involved. Hard copy output is classified in the domain of printers and discussed in 2.1.4. The display technologies described are divided into two categories: Group A—Vacuum Tube and Group B—Solid State.

Group A—Vacuum Tube Display Methods

- cathode ray tube
- plasma
- vacuum fluorescent
- filament
- gas discharge

TABLE 2-4. Comparison of Printer Technologies*

PRINTER	TECHNOLOGY UTILIZED	APPLICATION/ SPEED
Impact	Typewriter-style	Character by character
	(Print wheel, Drum, Ball)	Usually not over 30 CPS
	Dot-Matrix	Any range, but normally 30–120 CPS
	Hammer-style (Chain, Drum, Daisy)	Medium to high speed Usually line printer 200–1500 LPM
Non-Impact	Electrostatic	Can be page by page
	Electromagnetic	Medium—150 CPS
	Thermal	Usually character by character Limited columns
	Ink Jet	200–250 CPS
	Electrosensitive	Facsimile type (full page)

Group B—Solid-State Display Methods
- light-emitting diode
- liquid crystal
- electroluminescent
- miscellaneous displays

Group A—Vacuum Tube Display Methods

Cathode Ray Tube (CRT)

This display medium is the most widely used and least expensive of all the display techniques. Since the CRT has been used for a number of

TABLE 2-4. Continued

CHARACTERISTICS	COST	REMARKS
Noisy	Low	Long established—some reliability problems
Mechanical maintenance Variable font if ball		
High speed High resolution Variable font by circuitry Some graphics	Moderate	Wear can cause maintenance problems
	Higher	Long established
Analog or digital input Limited grey scale	Very high	Regular paper or special
Has potential for graphics	Moderate	Special paper
Compact High reliability, Simple to produce	Low	Becoming popular for other products Special paper
Requires cleaning	High	Regular paper
Simple construction Graphics (grey scale) Analog input Limited resolution	Moderate	Special paper

*CRC Report No. 127-1, "Data Terminal Technology—Present and Future Vol. I—State-of-the-Art." Communications Research Centre, Department of Communications, Ottawa, Ontario, April, 1975.

years as a display device in television receivers, technological improvements and reduced production costs have been passed on to the interactive display terminal market.

The CRT display module used in interactive terminals is similar to a television monitor. It consists of a CRT, a power supply, scanning and synchronization circuits, and a video input stage. A beam of electrons

enters the tube from the rear (see Figure 2-8) and its point of impact on the back of the tube face is controlled by electromagnetic fields set up across the path of the beam. Varying the strength of the fields moves the beam vertically and horizontally. When the beam hits the back of the tube face, it strikes a phosphor-coated surface and light is emitted. By varying the composition of the coating, different degrees of persistence can be achieved. A CRT used for computer output usually has relatively low persistence. This leads to the requirement that a display be regenerated or *refreshed* frequently, if it is to appear stable. Refresh rates of about 30 Hz (a minimum of 30 times per second) will cause the display to appear to be continuous and flicker will be avoided. Most current CRT displays have refresh rates of 50 to 60 Hz.

CRTs used in displays are divided into either of two classes:

1. small, relatively inexpensive terminals that display only a limited repertoire of characters in fixed positions on the screen (just as a typewriter is restricted in the choice and positioning of its characters)
2. larger, more expensive terminals which can generate any character and position it anywhere on the display surface.

Character formation can be under program control, or the characters may be formed by a software program which causes a pattern of dots or line segments to be displayed. There is no restriction on the size or style of characters with this technique. Some terminals have a built-in character generator. This technique uses electronic circuits to generate the dot pattern. Although it is faster, this technique gives less flexibility in the choice of characters than the software-generated display system. Another

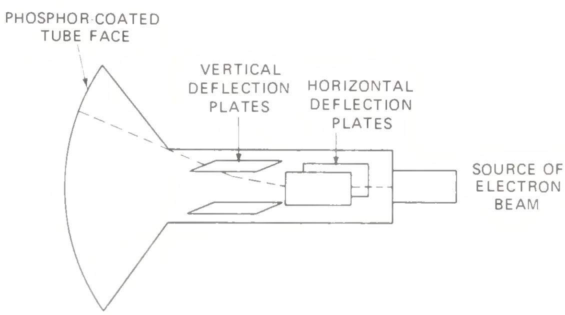


Figure 2–8. CRT schematic showing deflection plates, one of several techniques for controlling the position of the electron beam. (Source: Charles T. Meadow. *Man-Machine Communications*. New York: John Wiley & Sons, Inc., 1970.)

form of character generator uses a template. An array of shapes is introduced to produce an image pattern on the template, and then a second field positions the beam on the tube face.

Larger terminals have a vector or *line-drawing* capability, which is used for graphic display applications such as engineering design, curve-plotting, etc. When the origin and the end point of a line are established, a segment connecting these points is automatically generated. Sets of these segments may be used to generate characters, maps, graphs, or other images. Since the large amount of information required to generate complex graphics on a CRT display cannot be handled with a low transmission speed communications system, a direct high-speed interface with a host computer is required.

Refreshing the Display.[1] CRT displays, except those with storage tubes, require the image to be refreshed periodically. Any CRT display system must include a local memory with a capacity of between 250,000 and 400,000 bits per image, depending on other aspects of the system's operation. Any of several memory technologies can be used—delay lines, shift registers, ferrite core stacks, or magnetic disks—all techniques used in refresh memories. Of these, the magnetic disk is the least expensive for systems using many terminals because it can store the most data at the least cost per bit.

A disk storage unit designed to refresh a raster scan CRT must have a separate head for each data track, a high recording density, and a rotation rate that is highly stable and fast enough to refresh properly. The head-per-track design permits the disk to refresh several independent displays simultaneously. These heads must have individual read/write amplifiers, and they must be electrically isolated from one another to prevent crosstalk.

A standard television monitor requires just over 300,000 bits to display a single frame; additional disk capacity is required for horizontal and vertical retraces. Although the total refresh storage requirement could fit on three tracks of an ordinary magnetic disk, four tracks are used for simplicity in the control logic. This means that the images on 16 independent displays require 64 tracks.

Phosphors used in CRTs have differing decay times, and this property is used to simplify circuitry by eliminating the requirement for a refresh memory. This technique results in a slower interaction time, because a particular spot will continue to fluoresce for periods of time ranging from several seconds to minutes, depending on the phosphor, after the electron beam has ceased bombarding the screen. CRTs incorporating

[1]Charles T. Meadow. *Man-Machine Communications.* New York: John Wiley & Sons, Inc., 1970.

long decay time phosphors are referred to as *storage CRTs* or *storage tubes.*

Electron Beam Control. The high speed electron beam in these devices is controlled by one of two basic scanning techniques—random scan or raster scan.

Random Scan. The random scan technique is used most frequently in graphic terminals because it provides a better quality display than the raster scan technique. Visual quality is a subjective comparison based on a number of definable characteristics such as resolution, jitter, and intensity variation. This method uses a control technique to position the electron beam to form a specific character, line, or curve on the screen.

Raster Scan. The raster scan technique[2] uses the same electronic principle as the commercial television receiver. The electron beam scans the entire screen while the electron beam intensity is varied to form a character or other shape. Visual quality in the raster scan method is not as good as in random scan. Overall cost, however, is lower and it is possible to mix the display signal with the conventional television signal.

Both of these CRT scanning techniques have some cost advantages over other types of visual displays, but they are generally larger, require high voltage levels to operate, and are relatively fragile.

Color CRT[3]. Color CRT displays are capable of producing particular blocks of data which need to be brought to the attention of the operator. Conventional color television circuitry employs three separate electron beams to produce three distinct and separate colored dots on a screen, which appear as a single spot when viewed from a distance. Dot color is dependent upon the relative intensities of the individual dots. The use of three dots, rather than one, results in poor resolution. A more advanced technique—the color penetration principle—overcomes the resolution problem by using one electron beam and a multilayer phosphor screen. In this technique, each phosphor emits a different color when bombarded by the electron beam. The speed of the electron beam is the determining factor in the color produced. For example, a relatively low-speed electron beam will cause one phosphorous layer to illuminate, while a higher speed beam will cause the second layer to illuminate. This is shown in Figure 2-9.

Production of CRT components, both black and white and color, has become a highly automated process. However, the assembly of display packages used in interactive terminals which include power supplies, high voltage drive circuits, and other complex electronic circuitry is a process requiring a high labor content. The television receiver market, because

[2]Lawrence R. Lovercheck. "Raster Scan Technique." *Electronics,* June 5, 1972.
[3]Charles T. Meadow. *Man-Machine Communications.* New York: John Wiley & Sons, Inc., 1970.

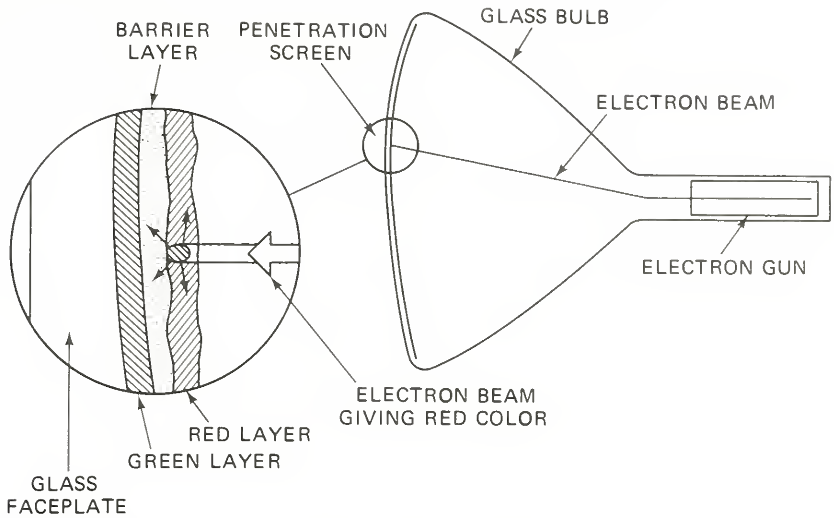


Figure 2–9. How a colored CRT produces colored images using the color penetration principle. (Courtesy, Department of Communications, Ottawa, Ontario, Canada.)

of its high volume requirement for CRTs, has developed some industry standards. The data terminal market does not yet represent a high volume demand and although some manufacturers have produced standards in certain performance characteristics, industry-wide standards (see Chapter 7) have not yet been developed. The lack of computer standards can make it more difficult to evaluate the performance of CRT-type displays, except by demonstration.

Plasma

This type of display uses a dot matrix to form characters using vertical and horizontal fine wire conductors from the anode and cathode of a gas discharge display at each cross point. A pattern is formed by energizing appropriate horizontal and vertical electrodes to create a matrix of light dots. The dimensions of the matrix are normally 5×7 (see Figure 2-10).

Plasma display panels are versatile devices because they are capable of displaying a number of patterns. They are, however, expensive and require relatively complex character generation logic to control the X and Y selection. High voltage and the requirement to select a number of dots to form one character add to the high cost.

Vacuum Fluorescent Tube

Vacuum fluorescent tubes have a vacuum tube glass envelope with a low voltage filament and seven anode segments. Electrons emitted by the filament are attracted to the phosphor-coated, positively-charged anodes.

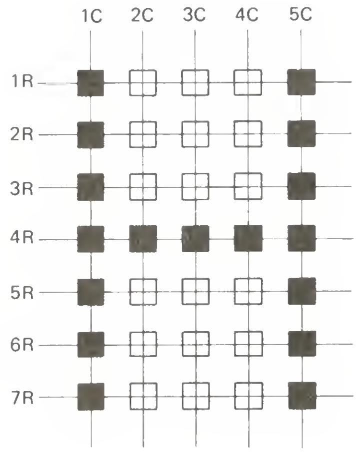


Figure 2–10. Five by seven dot-matrix display. (Courtesy, Department of Communications, Ottawa, Ontario, Canada.)

The anodes glow with a color ranging from blue to green. These devices are MOS-compatible, since their voltage requirements are in the 12 volt AC or DC range. Major advantages are ease of reading, low power, and reasonable cost. The fine filament structure, however, makes this type of display less rugged than others.

Filament

The normal *hot filament* incandescent lamp is the basis for this type of display. Hot wire filaments are placed near the front of a vacuum tube for direct viewing. The filaments normally are at half voltage to provide long life and reduced heat. The segments to be lighted are selected by the usual seven segment decodes described earlier. There are a number of variations of filament displays. In some cases, the lamp is located remotely and light is conducted to the viewing area by fiber-optic packages.

Filament displays have a number of advantages including high brightness, a variety of colors using filtration, and compatibility with transistor-transistor logic (TTL). They are, however, relatively fragile, require high power, and exhibit long on/off delay characteristics.

Gas Discharge

Gas discharge displays are *cold cathode* devices which incorporate discrete cathodes to represent numbers or letters. They are mounted behind each other and use a common anode. All of the elements are in a glass envelope containing an inert gas. A DC voltage of approximately 175 volts is applied to the anode of the gas discharge device. The cathode is

energized by grounding it through the control circuits, causing the surrounding gases to ionize. The physical shape of the cathode is outlined in the display of ionized gases around the energized control.

Another form of gas discharge display consists of straight segments which replace the shaped cathodes. The seven-segment display shown in Figure 2-11 is the most common device for this type. Illumination of different combinations of segments produces numbers and letters.

These devices have several advantages. They are rugged, economical, and relatively reliable. In certain applications, however, they have some disadvantages. Limited viewing angle and the requirement for a high voltage power supply can create a separate power requirement when used with computer logic circuits, which usually operate on a 5-volt supply.

Light output in most types is proportional to the forward current, up to the point of burnout, with the average current for most applications being relatively high. LED segments generally are mounted in a standard integrated circuit package, which may contain BCD-to-seven-segment converters for direct actuation of the segments. These devices have the advantage of ruggedness and a long operating life. They are most suitable for applications on consoles and calculators, where the calculator has sufficient current capability to provide proper illumination.

Group B—Solid-State Display Methods

Light Emitting Diodes (LED)

Light emitting diode readouts usually take the form of the seven-segment display in Figure 2-11. They utilize the properties of gallium phosphide (GaP), gallium arsenide (GaAs), or gallium arsenide phosphide (GaAsP), all of which emit light when a current flows across the semiconductor junction. Normally, a red light is emitted, but green, yellow, and blue lights also have been produced. LED fabrication techniques are similar to most semiconductor manufacturing methods. The devices are compatible with computer logic.

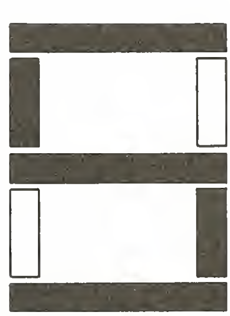


Figure 2–11. Seven-segment display. (Courtesy, Department of Communications, Ottawa, Ontario, Canada.)

Liquid Crystal

One of the most promising displays under development, with a potential for low cost, low power, and high performance, is the *liquid crystal display* (LCD). Liquid crystals differ from most other displays in that they depend on external light sources for their operation.

This display type is composed essentially of two parallel glass plates with conductive coatings on their inner surfaces. A liquid crystal compound, known as a *nematic*, is sandwiched between them. In the dynamic scattering display, the clear organic material becomes opaque and reflective when subjected to an electric field. Very low currents can create this effect and these devices typically operate in the microwatt region. As in other displays, the characters are usually built up from segments and driven by BCD-to-seven-segment converters.

LCDs require low power, have good readability, are compatible with computer logic, and are potentially low cost. The panels are very simple to construct, although quality control presents some problems in large volume production. Some limitation on the operating temperature range is a disadvantage, but presents no problem at normal room temperatures. Researchers expect this limitation will be overcome in the near future.

Electroluminescent

Electroluminescence is a photoelectric phenomenon which causes light to be emitted from a semiconductor material when it is placed in an electric field.

An electroluminescent cell consists of a transparent conductive glass substrate with a phosphor/dielectric layer and a second electrode applied to the opposite surface of the same substrate. The electrodes can be segmented as in other types of displays to form the required data readout. These cells are designed to operate on several hundred volts AC and are therefore difficult to interface with computer logic. Their main advantage is simplicity of fabrication.

A comparison of the different display technologies is shown in Table 2-5.

2.1.6 Data Transmission

Interactive data terminals are communicating devices which usually are remote from the host computer, at distances from a few feet to thousands of miles. Communication circuitry is an important aspect of every terminal, and there are a number of techniques used to interface a terminal with a communications network.

Short Distances—Line Drivers/Receivers

For relatively short distances (up to about a thousand feet) simple and inexpensive integrated cricuits, known as line drivers and receivers, may be used to obtain acceptable data error rates. Line drivers usually are inserted in a twisted pair of dedicated lines between the terminal and host computer. Data is transmitted over short distances in binary form (a "1" bit for current drive in one direction and a "0" bit for current drive in the opposite direction). Over very short distances, a single-ended mode of line driving is often used with current drive on one line only and the ground connection forming the return path. Differential drive is used where the line lengths exceed a few feet. It is the preferred mode since it eliminates line noise problems which frequently result from long ground loops. The cost of integrated circuit line transmitters and receivers is relatively low (ranging from $5 to $25 depending upon the features provided) and these devices are a small portion of overall terminal cost.

Long distance, multiple-port networks require common carrier communications facilities. One of the basic differences in operating characteristics between common carrier networks and digital equipment is that data terminals and computers use digital signals and telephone communications networks traditionally use analog communications methods. However, digital communication networks are being developed and refined, and a number of different classes of service are now being offered by common carriers.

Digital Networks

Although rapid expansion of these services is forecast over the next eight years, the capabilities of a completely digital, switched, data network are not expected to reach those of current analog networks within this time frame. Present digital networks do offer considerable transmission cost savings, for certain data rates, over comparable analog services. As the interface between the data terminal and the transmission medium becomes simpler with the extension of digital networks (no digital-to-analog and analog-to-digital conversion is necessary), data communication costs will decrease.

Modem Interface and Modulation Techniques

To use the facilities of the telephone network, *modems* have been used for several years, to interface the network to a variety of different items of digital equipment, particularly terminals and computers. Modem is an acronym for *mo*dulator–*de*modulator. In a data communications network, modulation is digital-to-analog conversion and demodulation is the reverse. The modem converts digital input to an analog form which

TABLE 2-5. Comparison of Display Technologies*

DISPLAYS	COMPETING TECHNOLOGIES	MAJOR APPLICATION AREA	NO. OF CHARACTERS	MAIN CHARACTERISTICS	LOGIC COMPATIBILITY	EXTERNAL REQUIREMENTS	REMARKS
Alphanumeric/ Graphic Displays	Cathode Ray Tube (CRT)	Display for interactive terminals Monitors	500-3,000	Display versatility Low cost Color capability	No	High voltage for tube operation Refresh memories Character gen	CRT displays are the lowest cost at present Physical bulk is a disadvantage Will continue to lead for low cost terminals
	Gas discharge (PLASMA)	Relatively small area displays Usually used for alphanumeric displays but have graphic capability	Up to 250	Flat compact display Digital scanning	No	X - Y drivers Relatively high voltages Read-only memory	These displays have been slow to impact the market place due to manufacturing problems creating high costs. Newer techniques are bringing costs down
Numeric - Alphanumeric	Liquid crystal (LCD)	Monitors Calculators Instrument readouts	1-10 (per assy.)	Low power requirement Well defined display TTL/MOS compatible	Yes	Requires external light source Read-only memory	This device has the most promise for challenging CRT in Alphanumeric use from a cost standpoint Normally grouped single character display

Numeric-Alphanumeric	Light emitting diode (LED)	Calculators Monitor panels Touchtone terminal displays	1-5 (per pack)	TTL Compatible Pleasant light display Low voltage Various colors	Yes	Read only memory TTL drivers	Can be used as dot matrix or segment displays. Bell labs currently involved in cost reduction for low power versions
	Electro luminescent (EL)	Aircraft panel display Monitors	1-5 (per pack)	Reliability Flat display large area	No	High AC voltage	Not very popular due to high voltages and limited light emission Normally used only in specific situations
	Gas Discharge (NIXIE)	Instrument readouts Monitors Calculators	1-15 (per assy.)	Defined characters No external character generation required	No	175 volts DC Normal drivers	Very popular over a great number of years Poor viewing angle performance due to paralax
	Vacuum Fluorescent	Computer consoles Small displays	1-15 (per assy.)	Low power Clear display Reliability	Yes	1.5v. AC/DC 12 v. DC	Excellent viewing display - but hot filament limits physical abuse
	Filament	Any display which has to operate under high ambient light conditions	1-10 (per assy.)	High brightness Versatility Easy viewing	Yes	12 - 24 v. lamp drivers	Any color display can be obtained by filtration Hot filament requires careful handling

*CRC Report No. 1276-1, "Data Terminal Technology—Present and Future Vol. I—State-of-the-Art," Communications Research Centre, Department of Communications, Ottawa, Ontario, April, 1975.

can be transmitted over the switched telephone network, and at the receiving end, converts the analog signal to a digital form acceptable to the digital device. Digital data for transmission may use one of several techniques to modulate the analog carrier signal:

1. amplitude modulation
2. frequency modulation
3. phase modulation

1. Amplitude Modulation (AM). One of the most common modulation techniques, amplitude modulation varies the amplitude of the transmitted analog carrier signal according to the characteristics of the modulating signal which represents the information to be transmitted. This technique produces new frequencies, above and below the carrier frequency. These are called upper and lower sidebands, and occupy a total bandwidth of twice the modulation rate. This transmission is called *double-sideband* AM. Since both sidebands convey the same information, they are mutually redundant. Therefore, modified systems (*single-sideband* AM and *vestigial-sideband* AM) have been developed to make AM transmission more efficient. In single-sideband AM, only one sideband is transmitted with or without the carrier, and the required transmission bandwidth is only half that required by double-sideband AM. Although single-sideband AM gives the best bandwidth economy, it requires relatively complex modulation/demodulation circuitry. This technique finds its most useful data communications applications in high-speed data transmission (4800–9600 baud) where channels are band-limited.

Vestigial-sideband AM transmits the desired sideband as well as some of the unused sideband and carrier. Special encoders are not required with this technique and conventional filters can be used. The bandwidth is approximately 1.3 times that of single-sideband AM and is often used in modems operating at transmission rates up to 7200 baud over voice-grade telephone lines.

2. Frequency Modulation (FM). This is a transmission technique where the carrier frequency is varied in proportion to the instantaneous value of the modulating signal. For transmitting binary data the frequency of the transmitted signal has one of two discrete values, one representing binary 1 and the other binary 0. This is called *frequency shift keying* (FSK).

Proper choice of modulation parameters yields an FM bandwidth of approximately the same order as a double-sideband AM system. When the transmission rate in bits per second numerically equals the frequency shift between the two binary levels, this situation will exist.

FSK modulation requires moderately complex circuitry and recent developments in integrated circuit phase-locked loops used in these circuits have resulted in significant cost decreases. The FSK technique has good noise immunity and permits some amplitude variations. Binary FSK is widely used for transmitting data, at rates up to 1200 baud, over voice-grade telephone lines.

3. Phase Modulation (PM). In this modulation technique, the phase of the transmitted carrier signal is varied in proportion to the instantaneous value of the modulating signal. Since digital data transmission involves only discrete phase shifts, *phase shift keying* (PSK) is used extensively in 2-phase, 4-phase, and 8-phase systems.

The most popular PM systems are 4- and 8-phase, because the required bandwidth may be reduced by factors of 2 and 3 respectively when compared with double-sideband AM systems. PSK techniques for binary data involve synchronous transmission with transmitter and receiver timing synchronized to allow coherent detection techniques.

PSK has the best tolerance to noise, but when differential detection methods are used, it is limited to synchronous operation. Differential 4-phase modulation uses the same bandwidth as binary single-sideband transmission, and is commonly used for synchronous operation at 2400 baud. Differential 8-phase modulation is used for synchronous operation at 4800 baud.

Interconnecting the Terminal to the Communications Network

Two basic interconnection techniques are used to connect a terminal to the communications network—modems and acoustic couplers. Modems are hardwired into the telephone network while acoustic couplers are "connected" via the telephone handset. Interconnection between modem or acoustic coupler and the data terminal is a hardwired connection. Signal levels for binary data transmission between the modem/coupler and the data terminal are dictated by an industry standard (EIA RS-232 C for example) specification (see Chapter 7). Some data terminals are manufactured with modems built into the equipment but, at present, the majority of terminals (see Chapters 5 and 6) have an RS-232 C or European equivalent (standard CCITT V. 24) interface to connect to an external modem.

Current Loop

Compatability with one of the most widely used terminals, the teletypewriter (TTY), requires a standard signal drive of 20 milliamperes in a current loop. Transmit and receive circuitry to simulate teletypewriter terminals is quite simple and inexpensive; however, since the transmis-

sion rate using a current loop is ordinarily 10 characters per second, it is used only where relatively long transmission times are acceptable.

Other Communication Characteristics

There are several characteristics of interactive terminals which relate to the communication techniques and standard operating procedures, for instance, availability of variable transmission speeds, half or full duplex transmission, block or full screen transmission, and parity (odd or even) checking. These characteristics are discussed in other chapters, and are included in the standard specification pages for each terminal in Chapters 5 and 6.

SIMPLE TERMINAL DEVICES— PERFORMANCE CHARACTERISTICS

3

3.1 INTRODUCTION TO THE SIMPLE TERMINAL

In the early days of data processing, as noted in Chapter 1, the primary interface with a computer was the teletypewriter, which consisted of a typewriter keyboard with printer and electronics to interface the device to the computer.

One of the workhorses of the industry has been the Model 33 data terminal (see Figure 3-1) by Teletype Corporation. Many thousands of these units were manufactured and have been installed around the world in hard copy communications applications, and as local control consoles in computer environments. Later models of simple terminals like the Model 33 incorporated CRT displays, frequently offering printer options to provide hard copy where required.

The basic definition of a simple terminal, as used in this handbook, is that it is not capable of being programmed by the user. Its operation is fixed as far as the user is concerned, either by design or by hardwired programming of certain operational functions by the manufacturer. Typically, simple terminals offer no editing, or limited editing capability, and cannot manipulate fields or records under user-programmed control as other types of terminals can.

The simple terminal, however, offers a number of advantages to users who must access a remote data processing facility, and have little need to perform local data processing operations as may be required of an intelligent terminal (see Chapter 4). These advantages include low cost, ease of maintenance, ease of operation, and a variety of data transfer rates and operating modes. Fixed data manipulation functions are frequently quite adequate to meet user requirements in a teleprocessing environment.

Figure 3–1. Typical simple terminal without display. Model 33 KSR. (Courtesy, Teletype Corporation.)

The two basic factors affecting terminal design and resulting performance characteristics relate to the terminal's interface with a telecommunications network and its interface with people—its ability to facilitate user-machine communications. Terminal operating features are a vital aspect of any data communications network. A poorly designed simple terminal can seriously affect the efficiency of the complete system by slowing down the system, reducing its usefulness, introducing errors, and significantly adding to its total cost.

For average data communications users the terminal is the most significant element since it is the only component they see. The effectiveness of a teleprocessing system is dependent largely upon selecting the right terminal to meet the task requirements. Generally, the performance characteristics of any simple interactive terminal should include the following:

response and output time fast enough to meet requirements

appropriate responses to displayed data

a display area large enough to meet data display requirements (display terminal)

ease of maintenance

readability of output, whether hard copy or displayed data

function and control keys to meet application requirements

convenience and ease of use in keyboard layout

Some of the applications where a simple interactive terminal can adequately meet user requirements are:

enquiry-response

data entry

text editing

instruction

information storage and retrieval

3.2 TWO GROUPS OF SIMPLE INTERACTIVE TERMINALS

Simple terminals described in this handbook have been divided into two basic groups on the basis of significant performance differences—simple terminals without display and simple terminals with display. The performance characteristics of each group are discussed in the following paragraphs.

3.2.1 Characteristics of a Simple Terminal without Display

These terminals are often referred to as *typewriter-like* devices because of their similarity to an electric typewriter. Key locations and functional operations are similar, and there is a hard copy output. They have the following general performance characteristics:

standard typewriter keyboard wtih function keys

printing speeds of 15 to 35 characters per second

line lengths from 72 to 132 characters

relatively low communications speed (typically 110 to 300 baud)

This group of terminals offers a low-cost interface between an operator and a host computer, and is used in many applications where no data processing functions are required at the terminal.

Their deficiencies are primarily lack of speed, which becomes more important as the host computer's ability to generate large volumes of data increases, and lack of graphic capability, which may be a disadvantage in

some applications. However, most simple terminals without display can be used to generate graphic material such as bar graphs, outline maps, and so on, at low data rates.

Function and Control Keys

In a simple terminal without display, there are relatively few special function and control keys. Those that are most often included on the keyboard are:

alternate character select

mode select

transmission rate select

line feed

break

tab

repeat

Printing Speeds

Printing speeds are generally not critical in applications where a simple terminal without display meets the data communications requirements. Low-speed printing (15–35 cps) is usually satisfactory for most of the typical applications shown in Section 3.1.

Line Lengths

A range of line lengths is available in the various models offered by manufacturers. These line lengths are similar to those available in medium and high speed line printers, and meet the requirements of most interactive terminal applications.

Communications Speed

The relatively low communications speeds available in a simple terminal wtihout display reflect the general areas of application for these devices. Typically, they are used where only low transmission rates are required.

3.2.2 Characteristics of a Simple Terminal with Display

Terminals with a display (typically a CRT, although other technologies, as discussed in Chapter 2, are actively under development) have the following characteristics (see Figure 3-2):

Figure 3–2. Typical simple terminal with display. (Courtesy, Applied Digital Data Systems, Inc.)

keyboard console with control and function keys (Figures 3-3 and 3-4)

display screen with display area, usually defined as a matrix of lines and characters

natural and efficient data entry facility

full range of communication speeds

The primary deficiency in the basic CRT interactive terminal is that no hard copy is available. However, virtually all manufacturers offer a printer option, and many applications do not require hard copy at the terminal site.

Keyboard assemblies for this group of displays are similar to those in the first group (terminals without displays), with the addition of control

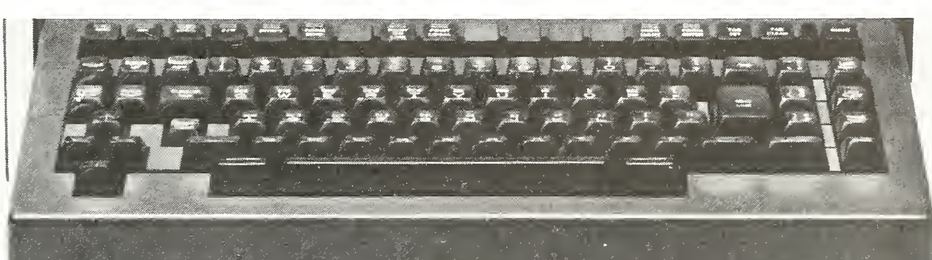


Figure 3–3. Typical basic keyboard layout for CRT terminal. (Courtesy, Teletype Corporation.)

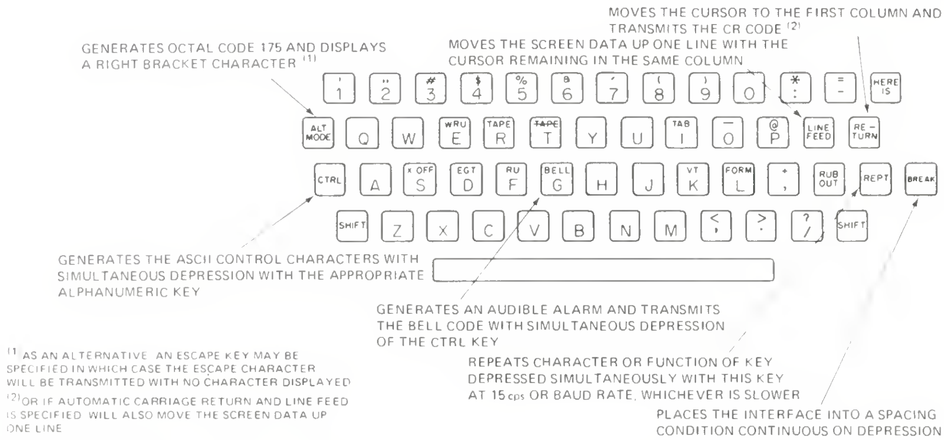


Figure 3–4. A typical keyboard used in a CRT interactive terminal, with functional description. (Courtesy Research Inc.)

keys and function keys related to the operation of the display. Control keys perform a variety of operations including cursor control, scrolling, and code data/command selection. Function keys are used to perform a number of display-oriented operations, and many terminals reserve some function keys for user-progammed operations (see Figure 3-5).

Transmission of *data only* is possible where the device is able to define fixed fields and labels. Full screen data transmission may be controlled from the keyboard and selected fields may be protected from user keying. Other function keys can erase various lines or selected characters, and can address a particular line, paragraph, or page.

Intensity variation, blinking, character reversal, and split screen operations also may be included. Underlining, widening selected characters, overstriking (often used for APL input), displaying selected characters in boldface, scrolling the display, and using hidden (nondisplayed) fields are all examples of the range of functions provided in interactive terminals with displays.

Readability

Readability and page layout are the key characteristics in choosing a CRT display. The following aspects should be considered:

1. Color—soft green background, or white characters on black are available. Size and shape of the characters also should be examined.

2. Function controls to block out characters in certain areas of the screen are useful for security.

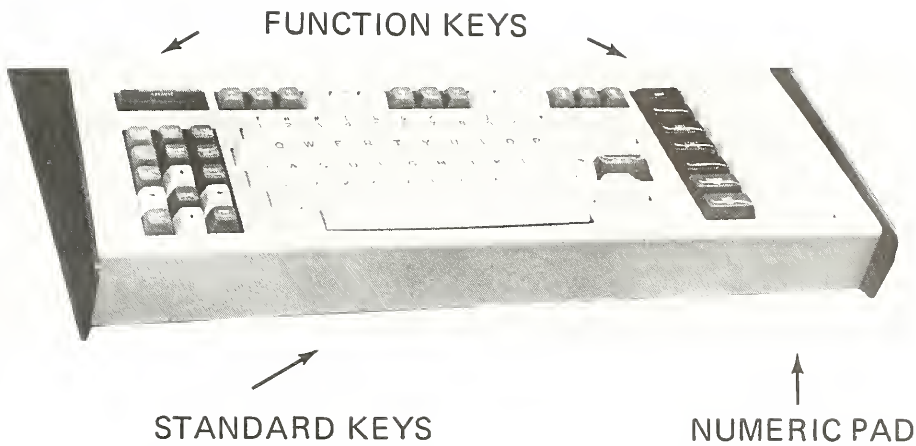


Figure 3–5. Typical display keyboard with function keys and numeric pad. (Courtesy, Megadata Computer and Communications Corp.)

3. Page design—choose a line/character matrix which will not put too much information on the screen. For example, 1920-character displays have too much data displayed at once, which tends to confuse the operator. In a typical application, as little as 10 percent of an enquiry page may be used on each access. Some users consider that a screen size of about 700 characters is an optimum for reducing transmission time and communications errors.
4. Error codes—errors by terminal user should be picked up immediately and an error message displayed. Flashing messages often are useful here.

Many display terminals are TTY-compatible; that is, they have a TTY interface capable of being used at the low data rates of a teletypewriter and in the same applications, with a printer option, if necessary.

Chapter 5 describes specific features of keyboard, display and communications, and provides evaluation guidelines for simple terminals with and without display, and specification pages for most terminals of this type offered by manufacturers. The specification format enables the user to evaluate and compare terminal characteristics in terms of performance and features.

INTELLIGENT TERMINALS—PERFORMANCE CHARACTERISTICS

4

4.1 DEFINING AN INTELLIGENT TERMINAL

The intelligent terminal segment of the computer terminal market has been growing rapidly over the past few years. The implementation of remote teleprocessing networks has been a major factor in this growth. Remote processing means using a computer facility from one or more locations geographically separated from the computer.

Generally, remote processing involves remote data entry as well as manipulation of data at the terminal. Intelligent terminals have found their greatest application in these areas, where the capability of interfacing with a variety of main frames and preprocessing data at the terminal are major considerations. Defining the properties of intelligence and the applications where intelligence at the terminal level is required is a difficult task, involving both hardware and network considerations (see Table 4-1).

TABLE 4-1. Typical data processing applications of intelligent terminals.

INTELLIGENT TERMINAL APPLICATIONS
Data preparation
Emulation of other terminals
Syntax-checking
Data editing
Complex buffering and polling

Distributed processing is a popular concept in teleprocessing circles and often intelligent terminals become *distributed processing systems,* ceasing to be items of individual equipment. Intelligent terminal manufacturers frequently define their terminal products as systems to emphasize versatility in a total processing environment.

The incorporation of a microprocessor in an interactive terminal provides it with the capability of being programmed. This is one of the key characteristics of intelligent terminals, as noted in earlier chapters. The second criterion is that the terminal must be capable of being programmed by the user.

4.1.1 User-Programmable[1]

Auerbach's *Minicomputer Reports*[2] defines an intelligent terminal as one that is *user-programmable.* As noted in Chapter 1, this is the definition adopted throughout this handbook. This definition separates terminals that are microprocessor-based with functions that are readily alterable by the user, and those which are programmed by the manufacturer or, in some cases, by the central processing unit (CPU). Software routines that provide the functions and capabilities in the simple interactive terminal (see Chapter 3) are unalterable by the user.

Preprogrammed simple terminals may be defined as *educable,* as opposed to being intelligent. Routines are stored in read-only memory (ROM) or programmable read-only memory (PROM) to which the user does not have access (see Chapter 6).

Although ROMs can be interchanged with other ROMs (with different capabilities) or with PROMs via a special engineering device, the concept of user programmability is not present (see Chapter 6).

An intelligent terminal, however, is easily modified by a user using standard language capability, such as an assembler which is designed for the interactive terminal microprocessor, a standard compiler language (FORTRAN or BASIC), or, more often, a specialized terminal language developed by the terminal supplier.

Terminal languages usually are simplified so users with only modest programming skills can develop programs to meet their own requirements. In particular, they are designed to facilitate record formatting, data entry, and data validation operations. They have limited computational instructions appropriate for the application.

[1]David C. Seigle. *Remote Processing with Intelligent Terminals.* Unpublished Paper, Ann Arbor, Michigan, 1975.

[2]Stephen J. Callahan, "Intelligent Terminals: It's a Matter of Definition." *Computing Canada,* February, 1976.

Initially, intelligence was used to enable one terminal to emulate another terminal device to meet a user's special requirements. Often manufacturers had to provide this feature so their equipment would be compatible with equipment from other suppliers' computers as well as other devices which interconnected in a data communications network. Programs used for emulation purposes were placed in ROM in earlier intelligent terminals.

This earlier capability has been expanded to cover a more general condition where programmability means many things to the user, as noted above, and may be used for any purpose—data entry, editing, formatting, etc.

4.1.2 Programmability Considerations

In current intelligent terminals, user programmability usually involves a special language, a random access memory, and a microprocessor.

User programmability at the terminal level has a number of advantages:

1. Line and mainframe loading can be reduced. Using a terminal at a remote site for editing and validation reduces turnaround time by eliminating error listings and remote rekeying.
2. Built-in obsolescence need not be a problem since the terminal operation can develop with the environment.
3. Customization is available down to the level of each remote site.
4. Flexibility is achieved through the user's ability to interface one terminal with different host computers.
5. Replacement of a mainframe does not create interface problems, since the terminal can be programmed to "talk" to any computer.

Programmability is accomplished with a special language which may be an assembler, or could be macro or procedural in form. These languages all have the common characteristics of allowing a CRT display to be formatted, and fields on the display to be addressed, as well as allowing formats and fields to be checked and edited as they are entered. Checking may take several forms; for example, the terminal can flag data which is non-numeric, out-of-range, improperly formatted, or otherwise unacceptable to the system. Editing functions may include table look-up and data replacement, extending two fields to replace another, calculating and inserting a check digit, etc.

The languages used to meet these programming requirements are

directed toward character or field processing rather than data processing. They also may have the capability of using other devices for input/output, editing, arithmetic capability, and report generation.

The acceptance and general popularity of intelligent terminals is due to their flexibility and data processing power, as well as to the reduced costs of components in memory and microprocessors. Frequently there is a trade-off between having more computing power at the host computer, at greater cost, and using the capabilities of one of the numerous varieties of intelligent terminals on the market.

4.1.3 On-Line and Off-Line

On-line intelligent terminals can be programmed by users to perform local checking of data and editing, and to bring formats from local storage rather than from a remote mainframe. This facility also enables users to reduce line traffic as well as the processing load on the host computer. The on-line terminal can be used to store data for later transmission in the batch mode by providing local storage, such as a flexible disk (often referred to as a *floppy* disk or *diskette*).

Off-line terminals do not offer the same degree of flexibility as the on-line type, but can be used to collect data and to check, edit, and store data for transmission to a mainframe at a more convenient time. Frequently, an intelligent terminal may be used in an off-line mode for special tasks. On-line terminals can function as off-line devices to transmit data or operate as enquiry/response facilities. With these features available, an intelligent terminal user has access to processing power which is independent of that provided by the mainframe.

4.1.4 Microprocessors and Processing Power

The heart of an intelligent terminal is usually a microprocessor—a small, powerful computer capable of driving a display and performing all of the computation required at the local level. The processing power of the internal microprocessor can be extended to perform other functions. The capabilities of this element may be used to store resident control software for a multi-task environment, which will enable a number of jobs to be run concurrently. A control program in the microprocessor may be used, for example, to permit data entry functions to be performed while printing is being done at the local line printer.

A disk-based data file is a natural alternative to the table look-up approach frequently used in the data entry process. In this situation, the intelligent terminal has the capability to access the file, using control

software which gives the programmer flexibility. This feature leads to other benefits relating to access to files which may only be important at the terminal site. For example, perpetual inventory files can be created and maintained locally. With the programmability of the intelligent terminal, files can be maintained as a by-product of the order entry process. Individual records may be examined at random. Figure 4-1 shows a typical intelligent terminal keyboard with appropriate control keys.

4.2 INTELLIGENT TERMINALS AND THEIR LIMITATIONS[3]

Since the intelligent terminal is essentially a key-entry device with the capability of supporting a variety of peripherals, including random access devices, there are some limitations to its use in a remote processing environment.

In a situation where key-entry is the primary application, intelligent terminals do not compare favorably to clustered key-entry systems on an economic (*price per terminal*) basis. The advantage of having access to a large disk locally is only one of the advantages of a more intelligent

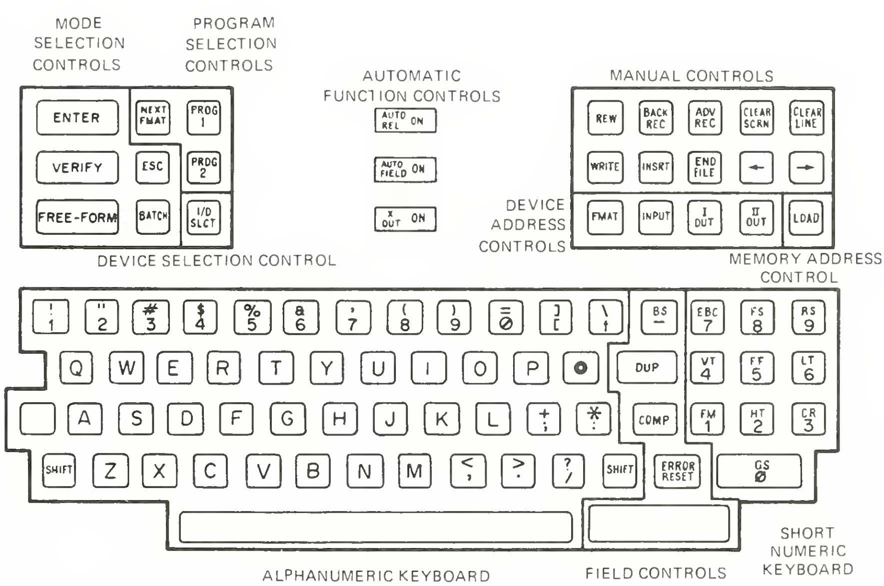


Figure 4–1. Typical keyboard layout for an intelligent terminal. (Courtesy, Olivetti.)

[3]David C. Seigle. *Remote Processing with Intelligent Terminals.* Unpublished Paper, Ann Arbor, Michigan, 1975.

data entry capability. The sharing of files which are available locally among several operators is also a significant benefit. This allows data entry operators to have access to current disk-stored information. Moreover, peripheral devices which cannot be shared, i.e. are dedicated to a single intelligent display terminal, do not represent an economical situation, and make the concept of multiple intelligent terminals at a remote site impractical.

Intelligent terminal processing systems have the advantage of being very beneficial at a remote site where limited data entry and remote processing is required. At sites where greater data entry capacity is needed, however, the high cost of display, lack of stored files, and duplication of peripheral devices precludes the use of intelligent remote processing.

4.3 CLUSTERED TERMINALS

Remote processing and user-programmed data entry are two concepts of the application of intelligent terminals which are being used extensively. There is obviously no reason for the concept of intelligent terminals to be limited to data entry tasks. Manufacturers of intelligent terminals have used the clustered terminal processing concept to good advantage in a variety of applications, as described in the following sections.

4.3.1 Multitasking with Clustered Terminals

Each display can perform as an independent intelligent terminal to provide the facility for user-programmed data entry, and software with multitasking capability can provide for concurrent operation and resource-sharing of each terminal facility and its peripherals. A well-designed system will offer compatibility of programming, communication, and operation among single terminal systems and clustered terminal systems. User flexibility in configuring a distributing processing network for small sites, as well as large sites, is thus enhanced. Training difficulties are minimized and a clear growth path is established for each remote site.

The sophisticated data processing capabilities of clustered systems require much more complex software requirements than those for an intelligent terminal. A number of software considerations are involved, including priority scheduling and lock-out mechanisms for shared-file accessing as well as security of information. In an intelligent terminal environment, and especially in the clustered terminal configuration, the remote processing of data imposes additional complexity on software through such requirements as:

use of remote files which correspond to equivalent subsets of corresponding host files

data-based facilities which are compatible with host facilities

compatible data definition

security and translation features

4.3.2 Future of Clustered Terminals

The future for clustered terminal systems will include the continual use of microprocessors for central logic and device control. These systems will be multi-processing and multi-programming facilities for data communication users.

Where a high-speed printer is available, reports can be generated if a high level data processing language, such as RPG, is included in the software capability of the intelligent terminal. Software facilities to support this capability require a variety of utilities, including sort, file, edit, and index file construction. Using all of this software requires both a job control and system software generation facility. These features are those found in a small computer system, and the intelligent terminal, in its higher levels of sophistication, obviously approaches the capability of a small computer (see Table 4-2).

4.4 THREE CATEGORIES OF USERS[4]

In the terminal market, intelligent terminals are gradually acquiring recognition as a "product," although the industry at large has yet to clearly define and accept the concept of intelligence as used in this handbook. There are, however, three broad application categories where in-

TABLE 4-2. Comparison of Minicomputer and Intelligent Terminal Characteristics.

MINICOMPUTER	INTELLIGENT TERMINAL
User programmable	User programmable
Large core memory	Limited core memory
Variety of peripherals	Variety of peripherals
Range of low and high level languages	Special terminal language
Communications capability	Communications capability

[4]David C. Seigle. *Remote Processing with Intelligent Terminals.* Unpublished Paper, Ann Arbor, Michigan, 1975.

telligent terminals are being used, and which give credibility to the user-programmable definition.

1. General-purpose intelligent terminals—used for data entry and data validation applications.

2. Intelligent terminal systems—clustered CRTs which enable processing power and resources to be shared. Intelligent remote job entry and interactive production runs are among the services provided by these *distributed processing systems.*

3. As an alternative to a range of different devices—minicomputers, small business computers, programmable calculators, etc.

Users from a broad industrial spectrum are demanding increased data processing capability from interactive terminals. The industry has responded with devices which can be programmed by the user to perform specific applications. Among users of intelligent terminals are those with a desire to own the latest terminal technology, those who believe that each individual terminal location needs a local programming capability, and those who perceive that many low level data processing functions can be performed at terminal sites, rather than at the host computer.

With the current high level of interest in data communications, intelligent terminals have not always been acquired on the basis of a sound evaluation of configuration requirements and in many cases do not represent an extension of capabilities over the nonintelligent devices they replaced.

Local programming capabilities offered by intelligent terminals can relieve the host computer from many of the routine housekeeping tasks in a data communications network. This aspect of intelligent terminals can delay or eliminate any requirement to move to a large host computer.

Intelligent interactive terminals offer sophisticated software routines for emulating different terminals and protocols, for data entry, data validation, and local editing. Even data base management is now available for implementation on some intelligent terminals. The user has the ability to modify the preprogrammed application packages using the capabilities of the intelligent terminal with interactive dialogue, one of the basic and most significant characteristics of these devices. The dialogue is in the form of prompting questions regarding record format, field entries, data type, etc.

[In Chapter 6, detailed evaluation guidelines are described with examples of how intelligent terminals can be used to enhance remote data processing.]

PART II

Evaluation and Standards

EVALUATING SIMPLE INTERACTIVE TERMINALS

5

The selection of a computer terminal for interactive communication with a computer, or in a network for communication with other terminals and peripheral devices can be a complex task. This is particularly true because of the multitude of terminals which are available to users in today's market.

The technology, as described in Chapter 2, is advancing rapidly. New methods of interacting and new techniques of producing output are continually being developed. There are many new developments in all areas which are combining to reduce costs, provide greater performance, and enhance the user/machine capability of the terminal. In this chapter, evaluation criteria for simple terminals with and without displays are discussed. The performance characteristics described in Chapter 3 form the background for this evaluation. The discussion of evaluation criteria is followed by a series of standard specifications for a comprehensive range of simple terminals. These specifications have been selected to match the evaluation criteria, where possible.

5.1 SIMPLE TERMINALS

Acquiring the correct terminal to perform a remote data entry task, where only a simple terminal is required, involves an evaluation of a number of operating characteristics.

In Chapter 3 the primary characteristics of simple terminals were examined and discussed. From this examination, two basic types of simple terminals emerged—keyboard without display and keyboard with display.

A user should initially select the basic type of terminal required for

the job. Both terminal types have advantages and disadvantages which should be evaluated against a particular application. A typical teleprocessing application with terminal functions is shown in Figure 5-1.

For example, if there is a considerable amount of hard copy required, then obviously a simple display terminal would not be suitable, unless it was provided with an optional printer unit. Alternatively, if a considerable amount of data must be *screened* but very little of this data is recorded, a display terminal could be a better choice.

The choice of a terminal for an interactive application will be based on a number of parameters related to the nature of the application. The required *speed* of operation is important, since the display type of ter-

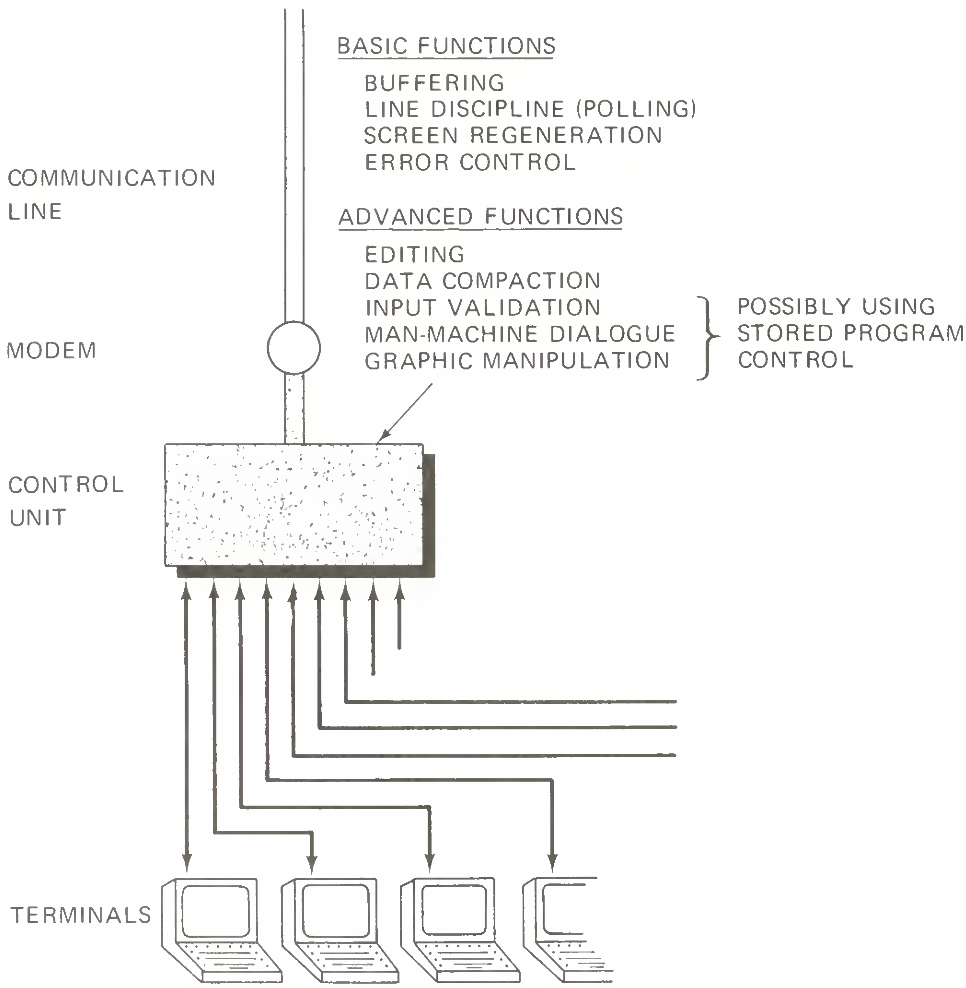


Figure 5–1. Typical application for simple terminals. Teleprocessing system showing elements and functions where terminals share a common control unit.

minal offers an immediate response characteristic which a printer does not possess. Interacting with a CRT, for example, provides a more *natural* user-machine communication environment than the nondisplay (keyboard/printer) terminal. Response is faster and productivity can be much higher in environments where a display-oriented terminal can be used.

5.1.1 Simple Terminal without Display

This type of terminal is characterized by a simple combination of the keyboard and printer mechanisms similar to the ordinary typewriter. A communication interface enables these devices to communicate with a computer and other terminals.

Keyboard

Chapter 2 described the various types of mechanical and electrical assemblies used in keyboards. Most of these techniques have been proven in service and are adequate to meet the needs of terminal users.

The standard typewriter key layout known as the QWERTY board, because of the arrangement of keys in the second row from the top, is used almost exclusively in interactive communication terminals (Figure 5-2). This layout defines the location of alphabetic and numeric keys, an obvious advantage in standardizing operator procedures, training, and effective use of interactive terminals.

Specific keyboard characteristics which are important in an evaluation of simple interactive terminals without display are:

character set

keyboard layout

function and control keys

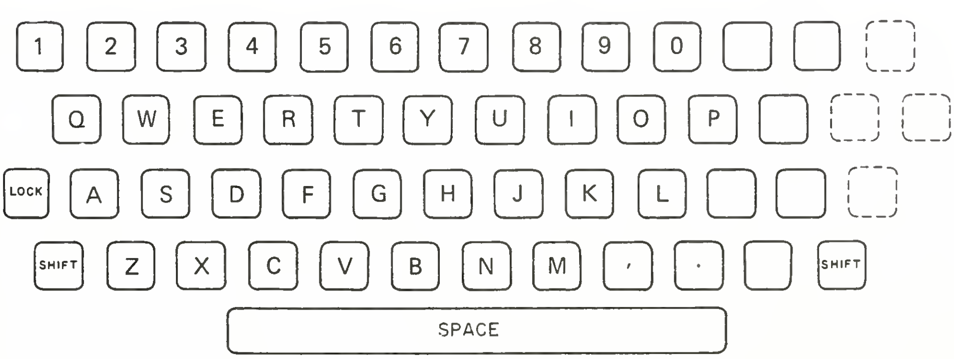


Figure 5–2. Typical QWERTY keyboard layout.

Table 5-1 provides some important keyboard considerations in selecting an interactive terminal.

Character Set

Standard character sets are provided with all interactive terminals described in this handbook. The character set of the terminal should be compatible with other character sets in any data processing environment, so that time-consuming translations from one character set to another are not necessary. Standard character sets include:

Table 5-1. Selection of Keyboard Characteristics in Interactive Terminals.[1]

FEATURE	PRESENT (√) OR ABSENT (×)
Can data be keyed into a buffer and modified before transmission?	( )
Is paper tape or any other serial medium used for buffering?	( )
Does the keyboard assist in formatting messages?	( )
Does it have the necessary keys for the required dialogue?	( )
Does it have special facilities to handle a computer failure?	( )
Can it be operated with one hand?	( )
Can key labels be changed?	( )
Does a bell ring at the end of a line?	( )
Are there good cursor controls?	( )
Are there facilities for easy modification of computer data?	( )
Are there SKIP and TAB keys?	( )
Are there PAGE or SCROLL keys?	( )
Are there YES/NO or other keys for high-speed scanning?	( )
Is the manual correction of errors easy?	( )
Can the numeric part of the keyboard be operated with one hand? (i.e. 3 × 4 matrix)	( )
Does the keyboard have a good "feel" to a fast-touch typist?	( )
Are HELP or INTERRUPT keys desirable in the man-machine dialogue?	( )
Does the input method have appropriate security features?	( )

[1]James Martin. *Introduction to Teleprocessing*. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1972.

ASCII (Figure 5-3. American Society for Communications and Information Interchange)

EBCDIC (Extended Binary Coded Decimal Interchange Code)

BCD (Binary Coded Decimal)

The ASCII character set ranges from about 64 to 128 upper-case characters, with lower case also available.

Other Keyswitches

The inclusion of a numeric pad (Figure 5-4) may be useful in some applications. Function (*control*) keys are used to perform a number of terminal operations, including selection of characters to be transmitted, transmission rate, device selection, repetition of characters, etc. (see Figure 5-5).

Display

Where a display is included with a simple terminal, the specifications for each display feature provided by the manufacturer also are included. These features are:

Format—a matrix of lines and characters, indicating the maximum number of characters which can be displayed on the display screen. The 5 x 7 dot matrix is the most common

Size—display size, usually in diagonal screen measurement or length and width

Character Set—the total number of standard characters available and the standard used (ASCII, USASCII, etc.)

Character Generation—the technology used for character generation —MOS and LSI techniques are used extensively here

Refresh Rate—displayed data or figures must be refreshed at rates which will retain a consistent intensity—most displays use a 60 Hz refresh rate

Cursor—a movable marker which can be controlled from the keyboard—it provides guidance for data entry, indicating where the next character will appear on the display. (Typically, cursors are blinking underline symbols, although other symbols also are used.)

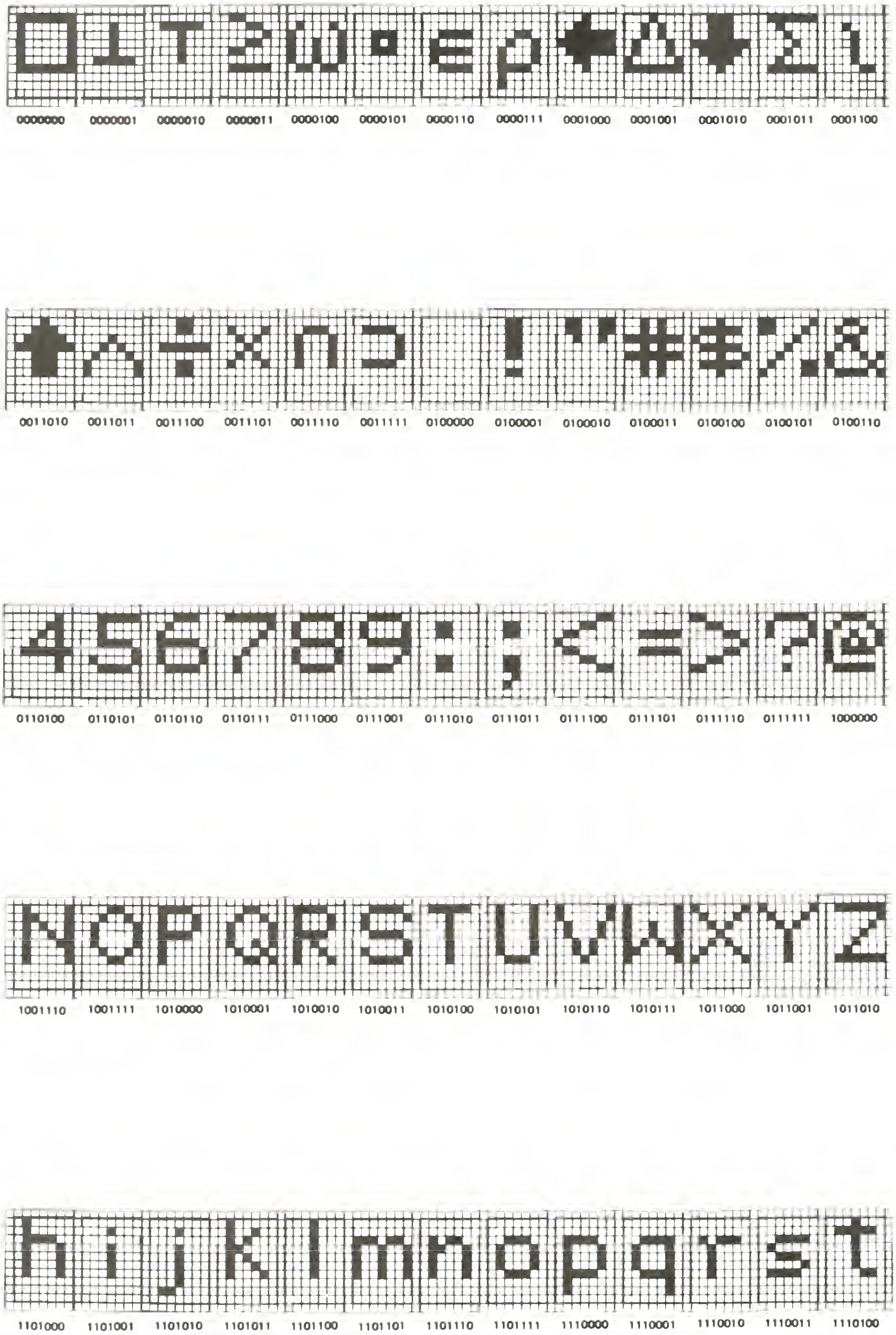
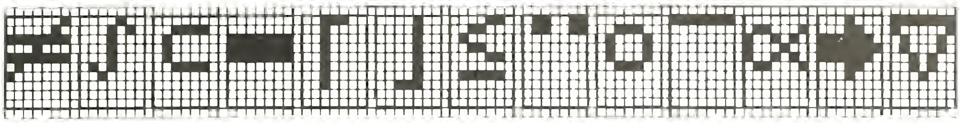
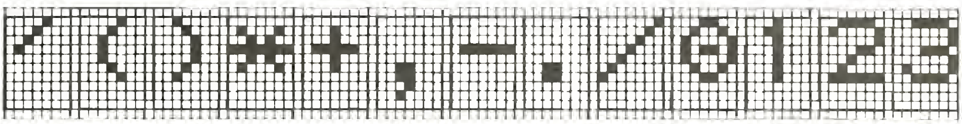


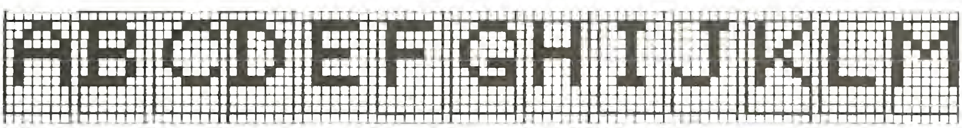
Figure 5–3. The 128-character ASCII set.



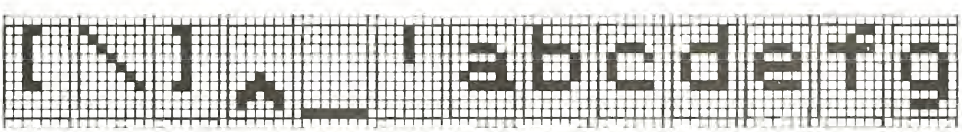
0001101 0001110 0001111 0010000 0010001 0010010 0010011 0010100 0010101 0010110 0010111 0011000 0011001



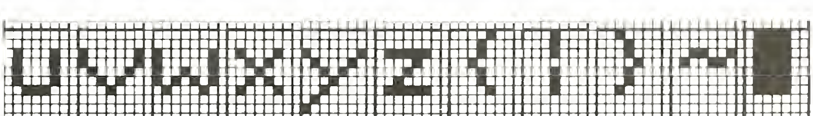
0100111 0101000 0101001 0101010 0101011 0101100 0101101 0101110 0101111 0110000 0110001 0110010 0110011



1000001 1000010 1000011 1000100 1000101 1000110 1000111 1001000 1001001 1001010 1001011 1001100 1001101



1011011 1011100 1011101 1011110 1011111 1100000 1100001 1100010 1100011 1100100 1100101 1100110 1100111



1110101 1110110 1110111 1111000 1111001 1111010 1111011 1111100 1111101 1111110 1111111

Figure 5–4. Typical numerical keyboard pad with ENTER key. (Courtesy, Digital Equipment Corp.)

Communications

Interface—this characteristic defines the capability of the terminal to interface with a data communications network—most terminals are designed to a standard prescribed by EIA RS-232 C (see Chapter 7), and some offer the alternative of a simple parallel or current loop interface

Maximum Transmission Rate—this characteristic refers to the maximum rate at which data can be transmitted—expressed in either bits per second (bps) or baud, a unit of information transfer

Mode—this characteristic defines the capability of a terminal to transmit and receive simultaneously (*full duplex*), or to perform only one of these operations at a time (*half duplex*)

Parity—this feature involves the checking and verification of transmitted data which is accomplished by inserting a parity bit to establish even or odd parity in a transmitted signal

Transmission Mode—this feature indicates the capability of a terminal to transmit data only or the total contents of the display screen

Table 5-2 provides some important operational and functional considerations for evaluating simple terminals with display.

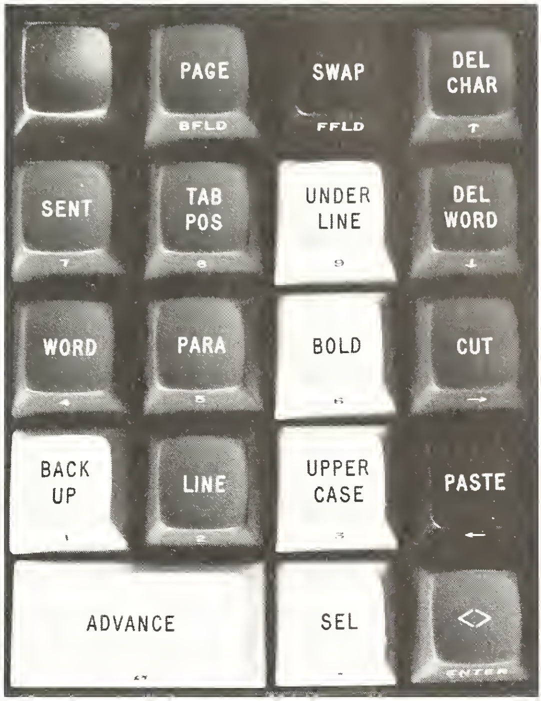


Figure 5–5. Typical control keys on a simple interactive terminal. (Courtesy, Digital Equipment Corp.)

5.2 SIMPLE TERMINAL SPECIFICATIONS

The following pages contain an extensive range of simple interactive terminal specifications based on information from suppliers and other industry sources.[2] Although these specifications describe most terminals available on the market today, there may be omissions due to:

rapid advances in technology and introduction of new terminals

similarity among models from a single supplier

Cost of terminals has not been included on the specification sheets because of changing supplier pricing structures. This is an area which is best-suited for discussion with suppliers on the basis of a specific requirement.

The information for these specification pages has been obtained from suppliers and other industry sources and is as current as publication schedules permit. Incomplete specifications reflect a lack of available information from suppliers at time of publication.

[2]Jackson W. Granholm. "Alphanumeric Display Terminals" *Datamation,* January, 1976.

Table 5-2. Selection of a Simple Terminal with Display.*

Does it have selectable horizontal tabs or other formatting features?

What editing capabilities are available?

Can individual fields be highlighted in some way—for example, by blinking, color, different brightness, or reverse field (either black characters on white or white characters on black)?

Are spaces to the right of an end-of-line character transmitted?

Does it have line addressing so that part of a display can be changed without altering the rest?

Can a protect field be used for selective data entry?

Are upper and lower case characters available for text editing?

Can it display enough characters?

Are displayed characters large enough?

Are characters easy to read?

Is it flicker-free?

Is the image bright enough?

Is the image suitably protected from external glare?

Is the display rate fast enough for man-machine dialogue?

Can it handle vectors or other graphic features?

Does it have destructive or nondestructive cursor?

Can the cursor be made either destructive or nondestructive under program control?

Are cursor movements possible?

Are keys for cursor movement straightforward?

Are character insert and delete capabilities available?

Does it have suitable special characters?

Is the character set large enough?

*James Martin. *Introduction to Teleprocessing*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

SIMPLE TERMINAL WITHOUT DISPLAY

Manufacturer	Model
Computer Transceiver Systems, Inc.	Execuport 300 (portable) Execuport 1200
Data Products	Portacom (Portable terminal)
Data Terminals and Communications	DTC-300/S
Digital Equipment Corp.	LA36 DECwriter II
IBM Corp.	3767 Models 1 and 2 3771 Models 1 and 2
Scope Data	Series 200
Teletype Corp.	Model 33
Texas Instruments, Inc.	743 745
Trendata Corp.	4000
Univac	DCT 500

MANUFACTURER
Computer Transceiver Systems, Inc.

MODEL
Execuport 300 (portable)

CHARACTERISTICS

Keyboard
Teletypewriter or full keyboard with numeric pad

Printer
Speed: 10, 15, 30 characters/sec
Line Length: 80 characters
Type: Non-impact

Communications
Code: EBCDIC/ASCII switchable
Interface: Integral acoustic coupler
Maximum Transmission Rate: 300 baud
Mode: Half or full duplex
Parity: Odd or even

Options
RS-232 C
Current loop

MANUFACTURER

Computer Transceiver Systems, Inc.

MODEL

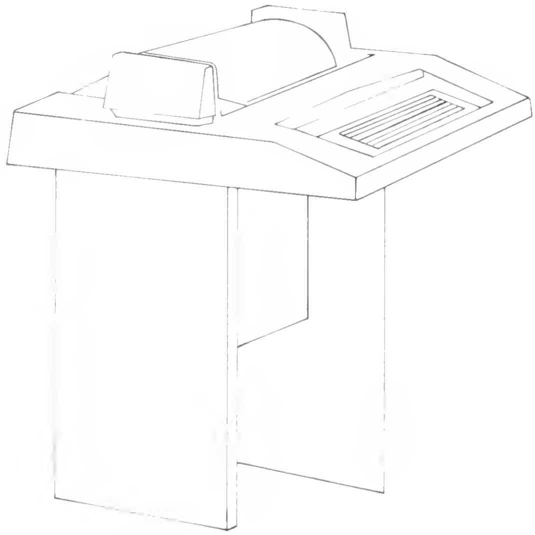
Execuport 1200

CHARACTERISTICS

Keyboard	Teletypewriter or full keyboard with numeric pad
Printer	
	Speed: 10, 15, 30, 60 and 120 cps asynchronous *Line Length:* 132 maximum *Type:* 5 x 7 dot matrix impact
Communications	
	Code: ASCII *Interface:* RS-232 C *Maximum Transmission Rate:* 1200 baud *Mode:* Half or full duplex *Parity:* Odd or even
Options	Keyboard with separate numeric pad EBCDIC/ASCII switchable Current loop

MANUFACTURER
Data Products

MODEL
Portacom (Portable Terminal)



CHARACTERISTICS

Keyboard — 128 USASCII; numeric pad; 13 math symbols

Printer

Speed: 10 characters/sec
Line Length: 80 characters
Type: Impact

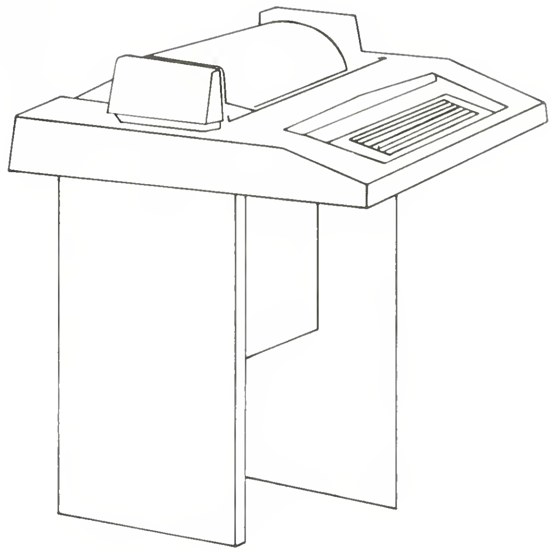
Communications

Code: ASCII
Interface: Acoustic coupler
Maximum Transmission Rate: 300 bps
Mode: Full duplex
Parity: Odd/even/inhibit

Options — RS-232 C

MANUFACTURER
Data Terminals and Communications

MODEL
DTC-300/S



CHARACTERISTICS

Keyboard	Selectric® style; 10-key numeric pad
Printer	*Speed:* 110, 150, 300 baud ASCII *Line Length:* 132 columns at 10 pitch 158 columns at 12 pitch *Type:* Impact
Communications	*Code:* Optional—BCD/Correspondence (APL compatible) *Interface:* RS-232 C, current loop *Maximum Transmission Rate:* 300 baud *Mode:* Half or full duplex *Parity:* Odd, even, all, none
Options	Multicode (ASCII, BCD, Correspondence) APL Engraved Key Caps Internal Modem Acoustic Coupler

MANUFACTURER
Digital Equipment Corp.

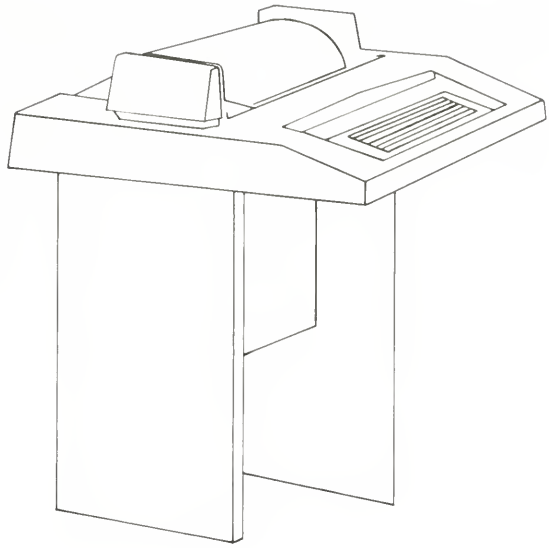
MODEL
LA36 DECwriter II

CHARACTERISTICS

Keyboard	ANSI 97 or 128 (switch selectable)
Printer	*Speed:* 30 characters/sec *Line Length:* 132 characters *Type:* Impact (7 x 7 dot matrix)
Communications	*Code:* ASCII *Interface:* Current loop *Maximum Transmission Rate:* 110, 150, 300 (switch selectable) *Mode:* Full duplex *Parity:* Odd or even
Options	RS-232 C Numeric pad

MANUFACTURER
IBM Corp.

MODEL
3767 Models 1 and 2



CHARACTERISTICS

Keyboard

Standard typewriter, 48 data keys (ASCII), 44 data keys (EBCDIC)

Printer

Speed: 40/80 characters/sec
Line Length: 132 characters
Type: Impact; bi-directional

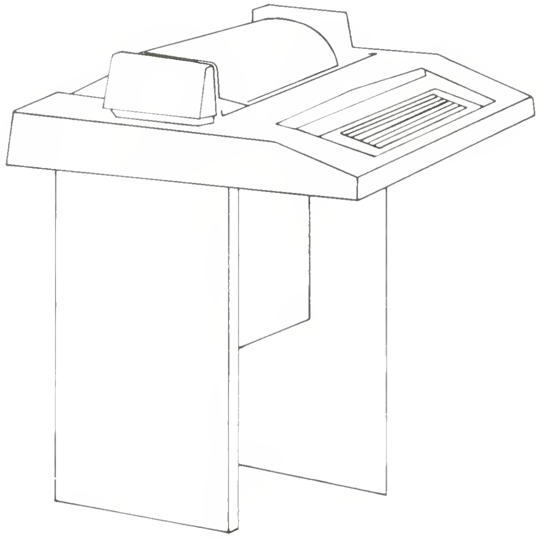
Communications

Code: EBCDIC or ASCII
Interface: RS-232 C
Maximum Transmission Rate: 2400 bps
Mode: Half duplex
Parity:

Options

MANUFACTURER
IBM Corp.

MODEL
3771 Models 1 and 2



CHARACTERISTICS

Keyboard

Typewriter, 44 keys (EBCDIC) or 48 keys (ASCII)

Printer

Speed: 40/80 characters per second
Line Length: 132 characters
Type: Impact

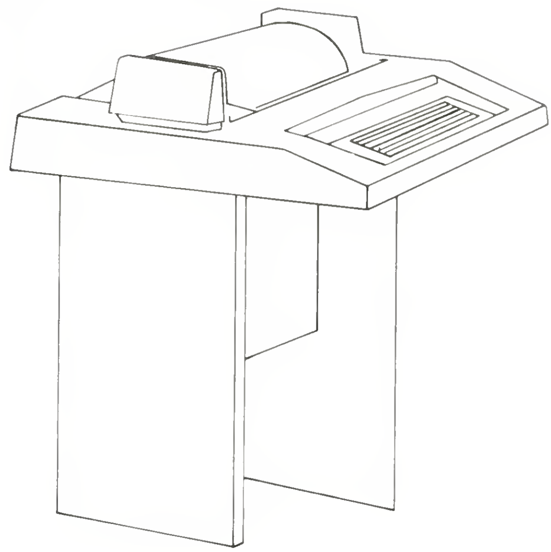
Communications

Code: EBCDIC or ASCII
Interface: RS-232 C
Maximum Transmission Rate: 9600 bps
Mode: Half duplex
Parity:

Options

MANUFACTURER
Scope Data

MODEL
Series 200



CHARACTERISTICS

Keyboard — Standard TTY; no numeric pad

Printer

Speed: 120 characters per sec
Line Length: 80 characters per line
Type: Non-impact

Communications

Code:
Interface: Serial only RS-232 C
Maximum Transmission Rate: 1200 baud asynchronous
Mode:
Parity:

Options — Special character and code sets
Special interfaces
High speed options (up to 240 characters/sec)

MANUFACTURER
Teletype Corp.

MODEL
Model 33

CHARACTERISTICS

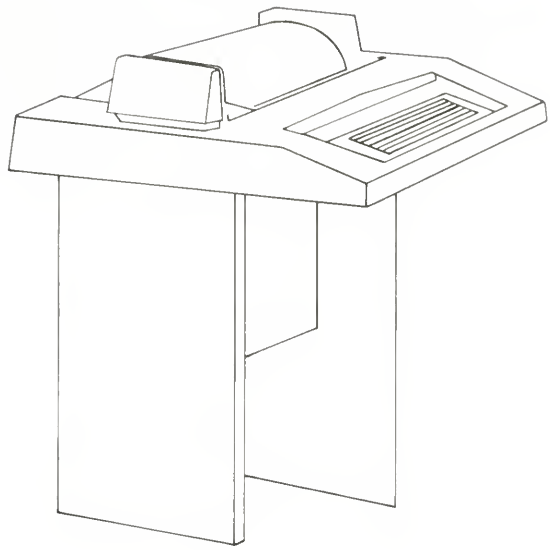
Keyboard	4-row, 8-level, typewriter ASCII C
Printer	*Speed:* 10 characters/sec *Line Length:* 72 characters *Type:* Impact
Communications	*Code:* ASCII (7 information, 1 parity) *Interface:* Built-in modem compatible with Bell System 103 *Maximum Transmission Rate:* 110 baud *Mode:* Half or full duplex *Parity:* Even
Options	RS-232 C interface Paper tape read/punch

MANUFACTURER

Texas Instruments, Inc.

MODEL

743

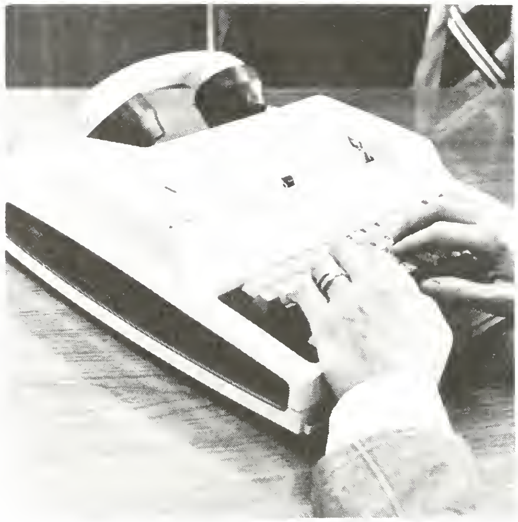


CHARACTERISTICS

Keyboard	Standard ASCII—numeric key pad and two-key rollover
Printer	*Speed:* 10 and 30 characters per second *Line Length:* 8 inches; 10 characters per inch; 80 characters per line *Type:* Non-impact
Communications	*Code:* USASCII; 7-level, 11 bits/ character including parity *Interface:* *Maximum Transmission Rate:* *Mode:* Half or full duplex (switch selectable) *Parity:* Optional odd, even, or mark (factory set)
Options	Answer back memory Internal modem

MANUFACTURER
Texas Instruments, Inc.

MODEL
745

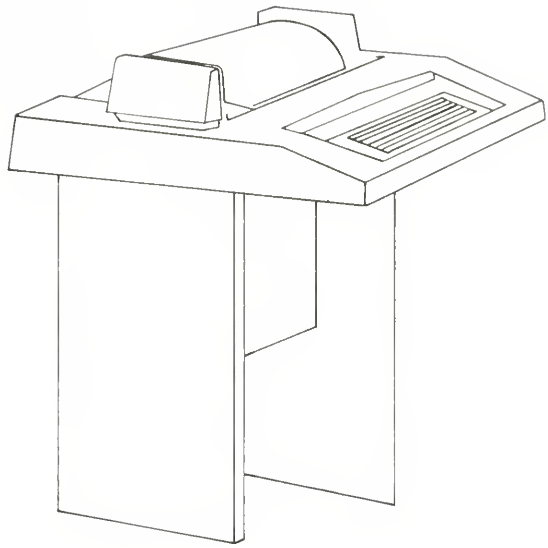


CHARACTERISTICS

Keyboard	ASCII; numeric pad embedded, 2-key rollover, 97 codes generated
Printer	*Speed:* 10-30 characters per sec (selectable) *Line Length:* 80 characters *Type:* Non-impact
Communications	*Code:* USASCII 7-level *Interface:* Acoustic coupler *Maximum Transmission Rate:* 110 or 300 baud (switch selectable) *Mode:* Half or full duplex *Parity:* Optional odd, even, or mark (factory set)
Options	Auxiliary EIA interface (RS-232 C) Answer back memory

MANUFACTURER
Trendata Corp.

MODEL
4000

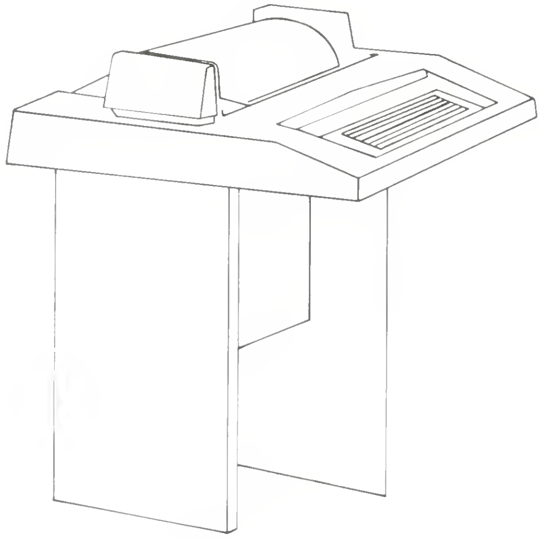


CHARACTERISTICS

Keyboard	N-key rollover; two-key lockout communication control keys; numeric pad
Printer	*Speed:* 30 CPS *Line Length:* *Type:* Impact
Communications	*Code:* USASCII *Interface:* *Maximum Transmission Rate:* *Mode:* *Parity:*
Options	

MANUFACTURER
Univac

MODEL
DCT 500



CHARACTERISTICS

Keyboard
128-character ASCII

Printer

Speed:
Line Length: 132 characters
Type: Impact

Communications

Code: ASCII
Interface: RS-232 C or CCITT
Maximum Transmission Rate: 300 baud, switch selectable, asynchronous
Mode: Half or full duplex
Parity:

Options

SIMPLE TERMINAL WITH DISPLAY

Manufacturer	Model
Ann Arbor Terminals	2050
Applied Digital Data Systems, Inc.	Envoy 620 (portable) Consul 920 Consul 580/MRD 380 Consul 980 A MRD 460
Beehive Medical Electronics, Inc.	Mini Bee 2 Super Bee 3 Mini Bee 4 Speedi-Bee 8 Edit-Bee
Bunker Ramo	BTS 2060
Burroughs	TD 700 TD 800 TD 820
Computer Communications, Inc.	CC-40
Computer Optics, Inc.	7277-1
Conrac	480/25
Control Data Corp.	OEM 92451/92452 711-10 713-10 (TTY-compatible) 714
Courier Terminal Systems, Inc.	270
Data General Corp.	6012
Datamedia	Elite 1500 and 2500
Datapoint Corp.	3300 Interactive Terminal Datastation 3600

Manufacturer	Model
Delta Data Systems Corp.	Delta 4000 Delta 5000/APL 5270 Delta 5500
Digital Equipment Corp.	VT-50 VT-52
Digi-Log Systems, Inc.	Telecomputer II
Four-Phase Systems	IV/40 and IV/70
GTE/IS	IS/7000
Genesis One Computer Corp.	G77
Goodwood Data Systems, Ltd.	GDS 300
Hazeltine Corp.	Modular One Hazeltine 1200 2000
Honeywell	VIP 7700
IBM	3277 Models 1 and 2
ITT	3100 Alphascope 3501 ASCIscope
Informer, Inc.	D301/302
Infoton, Inc.	Vistar Vistar/Satellite Vistar/GTX
International Communications Corp.	40+
Kustom Data Communications, Inc.	MCT 10
Lear-Seigler	ADM-1 ADM-2 Executive
Lektromedia	LEK 104 LEK 104 Graphics Terminal
Megadata Computer and Communications Corp.	SIR 1000 Powerscope

Manufacturer	Model
Micro Application Systems	T1
Olivetti	DSY 8060
Pertec Business Systems	700
Princeton Electronic Products, Inc.	801
Research, Inc.	Teleray Series 3300 Teleray Series 3500 Teleray Series 3700
Scientific Measurement Systems, Inc.	SMS 1920
TEC, Inc.	Series 400 (11 models) Mini-TEC 1400 and 2400 Tele-Tec 1440
Tektronix, Inc.	Tektronix 4006-1 Tektronix 4023 Tektronix 4051
Teleram Communications Corp.	P-1800
Teletype Corp.	Model 40 40/1 40/2
Terminal Communications, Inc.	TC-275 TC-277
Texas Instruments, Inc.	913 914A Video Terminal
Trivex, Inc.	Plus 70 40/80
Univac	Uniscope 100
Video Data Systems	CG-500
Wintek Corp.	B-R-B Video Terminal
Wyle Computer Products, Inc.	8000 Series

MANUFACTURER
Ann Arbor Terminals

MODEL
2050

CHARACTERISTICS

Keyboard

Upper case TTY with separate cursor and numeric pad

Display

Format: 20 lines x 50 characters
Size: 14″ CRT
Character Type: 7 x 9 dot matrix
Character Set: 96-character ASCII; upper and lower case
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Underscore

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 baud
Mode: Half or full duplex
Parity: Odd
Transmission Mode: Optional data or full screen

Options	Current loop interface, TTL, Additional transmission rates Screen transmit Other models have various display characteristics

MANUFACTURER

Applied Digital Data Systems, Inc.

MODEL

Envoy 620 (portable)

CHARACTERISTICS

Keyboard

ASCII; function pad

Display

Format: 24 lines x 80 characters; black and white
Size: 5″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: CPU-controlled

Communications

Interface: Acoustic coupler 110/300 baud
RS-232 C, current loop
Maximum Transmission Rate: 300 baud (acoustic coupler up to 9600 baud, switch selectable)
Mode: Half and full duplex, switch selectable
Parity: Odd, even, mark, space
Transmission Mode: Character-by character

Options

MANUFACTURER
Applied Digital Data Systems, Inc.

MODEL
Consul 920

CHARACTERISTICS

Keyboard

ASCII; numeric pad and printer control pad

Display

Format: 24 lines x 80 characters; black and white
Size: 12 "CRT"
Character Type: 5 x 7 dot matrix
Character Set: 96-character upper/lower case
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: CPU-controlled

Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 baud
Mode: Half and full duplex, switch selectable
Parity:
Transmission Mode: Character-by-character, block, page

Options

MANUFACTURER
Applied Digital Data Systems, Inc.

MODEL
Consul 580/MRD 380

CHARACTERISTICS

Keyboard

ASCII; numeric pad and printer control pad

Display

Format: 24 lines x 80 characters; black and white
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 128-character plus lower case
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: CPU-controlled

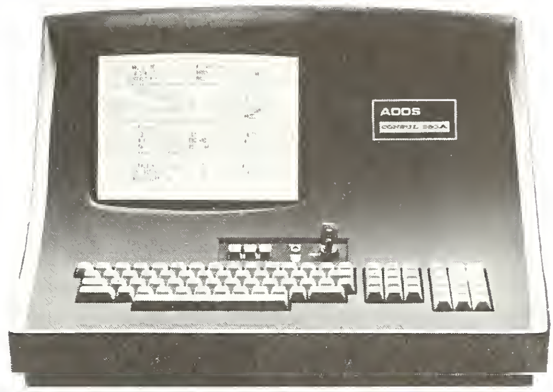
Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 asynchronous
Mode: Half and full duplex, switch selectable
Parity: Odd, even, mark, space
Transmission Mode: Character-by character and block

Options

MANUFACTURER
Applied Digital Data Systems, Inc.

MODEL
Consul 980 A

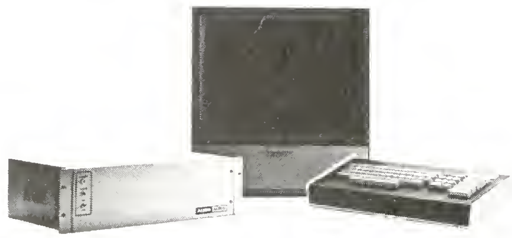


CHARACTERISTICS

Keyboard	ASCII; 12-key numeric pad, printer control pad
Display	*Format:* 24 lines x 80 characters *Size:* 12″ CRT *Character Type:* 5 x 7 dot matrix *Character Set:* 96-character including lower case *Character Generation:* MOS *Refresh Rate:* 60 *Refresh Memory:* MOS *Cursor:* CPU-controlled
Communications	*Interface:* RS-232 C *Maximum Transmission Rate:* 9600 baud asynchronous, 10,800 synchronous *Mode:* Half and full duplex *Parity:* Odd, even, mark, page *Transmission Mode:* Character-by-character, block
Options	

MANUFACTURER
Applied Digital Data Systems, Inc.

MODEL
MRD 460



CHARACTERISTICS

Keyboard (optional)
TTY-compatible

Display (color)

Format: 24 lines x 80 characters
Size: 14″/25″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character upper case ASCII
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: Color; flashing; CPU-controlled

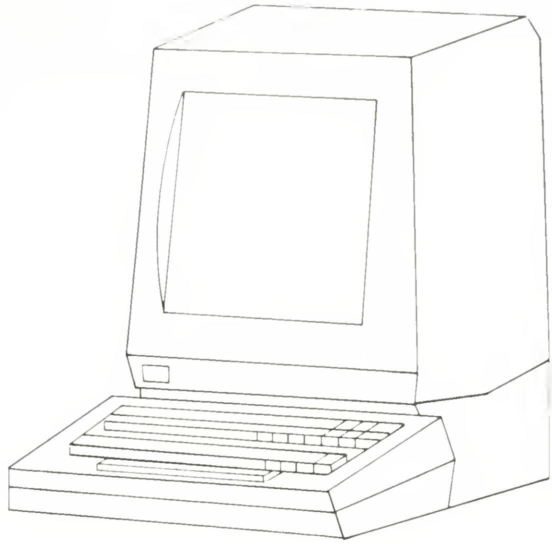
Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 baud
Mode: Half and full duplex, switch selectable (with keyboard option)
Parity: Odd, even, mark, space
Transmission Mode:

Options

MANUFACTURER
Beehive Medical Electronics, Inc.

MODEL
Mini Bee 2



CHARACTERISTICS

Keyboard	Standard TTY keyboard, custom designed, detachable module
Display	*Format:* 25 lines x 80 characters *Size:* Approximately 8.4″ x 6.5″ *Character Type:* 5 x 7 dot matrix—Two dot spacing between characters; white on black *Character Set:* 64-character ASCII *Character Generation:* MOS ROM *Refresh Rate:* 60 Hz *Refresh Memory:* MOS shift register *Cursor:*
Communications	*Interface:* Serial RS-232 C *Maximum Transmission Rate:* 9600 bps asynchronous (switch selectable) *Mode:* Full duplex, half duplex *Parity:* Odd, even, mark, space *Transmission Mode:* Character-by-character transmission

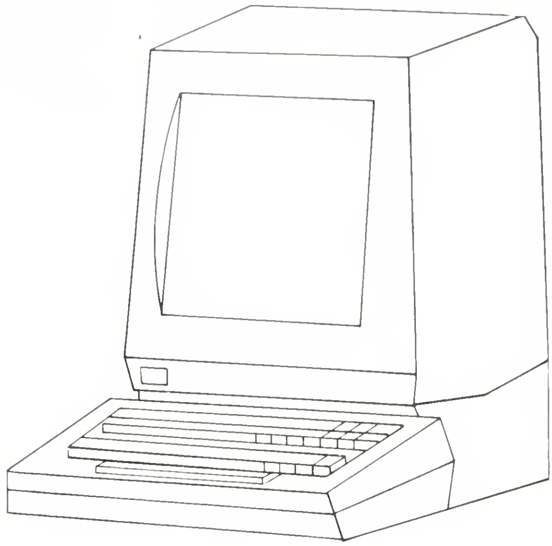
Options	11-key numeric keyboard
	Export configuration—50 Hz 230 Volts
	—50 Hz 115 Volts

MANUFACTURER

Beehive Medical Electronics, Inc.

MODEL

Super Bee 3



CHARACTERISTICS

Keyboard

Eight lighted mode indicator switches; auto repeat; logically paired ANSII configuration; 11-key numeric pad includes decimal point

Display

Format: 25 lines x 80 characters
Size: Approximately 8.4″ x 6.5″
Character Type: 5 x 7 dot matrix—Two dot spacing between characters; white on black
Character Set: 128-character ASCII displayable
Character Generation: MOS ROM
Refresh Rate: 60 Hz
Cursor:

Communications

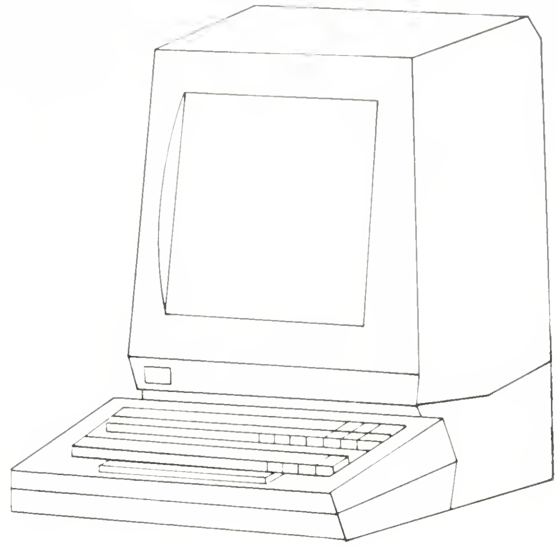
Interface: Serial RS-232 C
Maximum Transmission Rate: Switch selectable to 4800 baud, synchronous/asynchronous
Mode: Full duplex, half duplex

Parity: Asynchronous—Even/None
Synchronous—Odd/None
Transmission Mode: Page or block

Options

MANUFACTURER
Beehive Medical Electronics, Inc.

MODEL
Mini Bee 4



CHARACTERISTICS

Keyboard — 80-key detachable

Display

Format: 25 lines x 80 characters
Size: 8.4″ x 6.5″
Character Type: 5 x 7 dot matrix
Character Set: 128-character displayable
Character Generation: MOS ROM
Refresh Rate: 60 Hz, 50 Hz (strap selectable)
Refresh Memory: MOS shift register
Cursor: Nondestructive, blinking underscore

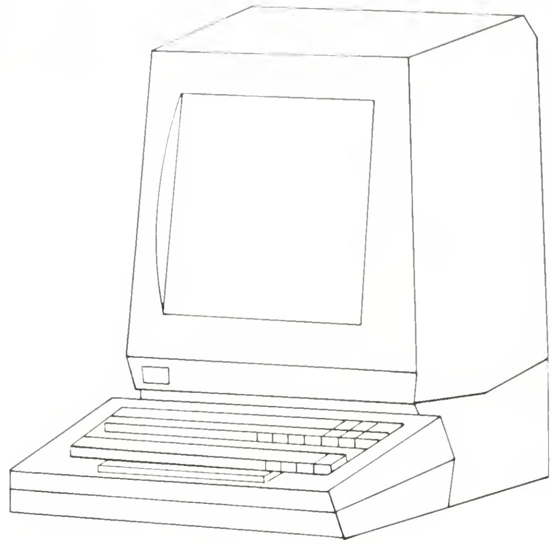
Communications

Interface: Serial RS-232 C
Maximum Transmission Rate: 9600 bps (switch selectable)
Mode: Full duplex, half duplex
Parity: Odd, even, mark, or space strap selectable
Transmission Mode: Character-by-character transmission

Options	Composite video Rack mountable Current loop Block send/print custom ROM Export—50 Hz

MANUFACTURER
Beehive Medical Electronics, Inc.

MODEL
Speedi-Bee 8



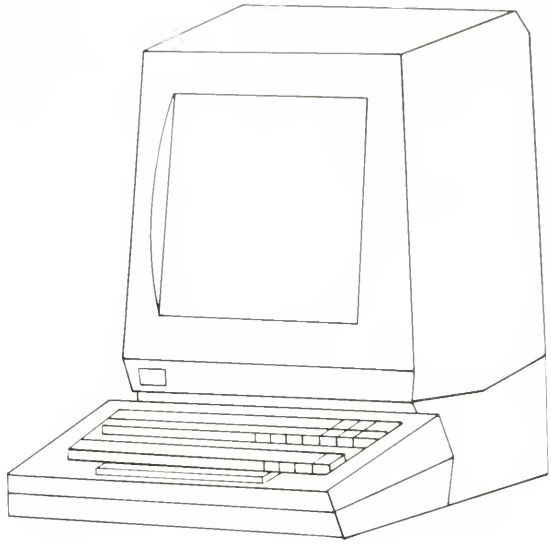
CHARACTERISTICS

Keyboard	80-key detachable
Display	*Format:* 25 lines x 80 characters *Size:* 8.4″ x 6.5″ *Character Type:* 5 x 7 dot matrix—Two dot spacing between characters; white on black *Character Set:* 128-character displayable *Character Generation:* MOS ROM—raster scan *Refresh Rate:* 60 Hz, 50 Hz strap selectable *Refresh Memory:* 7 x 2048 bit N-MOS static RAM *Cursor:* Nondestructive, blinking underscore
Communications	*Interface:* TTL 8-bit parallel; 8 or 12 bit input *Maximum Transmission Rate:* 500 K char/sec

	Mode: Half duplex *Parity:* Odd, even, mark, or space strap selectable *Transmission Mode:* Character-by-character transmission
Options	Several keyboards available 25 lines x 40 characters Export—50 Hz Rack mountable Simple graphics Programmable keyboard

MANUFACTURER
Beehive Medical Electronics, Inc.

MODEL
Edit-Bee



CHARACTERISTICS

Keyboard	Typewriter-layout plus special keys (optional)
Display	*Format:* 25 lines x 80 characters *Size:* 15″ CRT *Character Type:* 7 x 9 dot matrix *Character Set:* 256-character displayable *Character Generation:* *Refresh Rate:* 50 Hz *Refresh Memory:* MOS *Cursor:*
Communications	*Interface:* RS-232 C *Maximum Transmission Rate:* 9600 baud (selectable) *Mode:* *Parity:* Odd or even *Transmission Mode:*
Options	Pseudo poll Programmable keyboard Custom polling protocol

MANUFACTURER
Bunker Ramo Corp.

MODEL
BTS 2060

CHARACTERISTICS

Keyboard — Upper and lower case; numeric pad

Display

Format: 25 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 128-character ASCII
Character Generation: MOS ROM
Refresh Rate:
Refresh Memory:
Cursor: Nondestructive, blinking underscore

Communications

Interface: RS-232 C
Maximum Transmission Rate:
Mode:
Parity:
Transmission Mode:

Options

MANUFACTURER
Burroughs Corp.

MODEL
TD 700

CHARACTERISTICS

Keyboard

Display

Format: 8 lines x 32 characters
Size: 9.2″ x 3.4″
Character Type: 5 x 7 dot matrix
Character Set: 64-character
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Burroughs Corp.

MODEL
TD 800

CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 9.5″ x 7.5″
Character Type: 5 x 7 dot matrix
Character Set: 96-character (including lower case)
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Burroughs Corp.

MODEL
TD 820

CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 9.5″ x 7.5″
Character Type: 5 x 7 dot matrix
Character Set: 96-character (including lower case)
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Computer Communications, Inc.

MODEL
CC-40

CHARACTERISTICS

Keyboard

68 keys, ASCII, Electronic key switches, N-key Rollover

Display

Format: 24 lines x 40/80 characters
Size: 11″ CRT
Character Type: 5 x 7 dot matrix
Charcter Set: 128-character including lower case
Character Generation: MOS
Refresh Rate: 60/50
Refresh Memory: MOS/RAM
Cursor: Move/read by CPU or keyboard

Communications

Interface: RS-232 C, parallel
Maximum Transmission Rate: 9600 baud
Mode: Half or full duplex
Parity: Even
Transmission Mode: Full screen

Options

Color display
Light pen
Parallel local output
Non-standard character set
Audible alarm

MANUFACTURER
Computer Optics, Inc.

MODEL
7277-1

CHARACTERISTICS

Keyboard

EBCDIC, ASCII, 66- and 78-key configurations available; function keys and numeric pad (optional)

Display

Format: 12 lines x 40 characters
Size: 15″ CRT
Character Type: 7 x 9 dot matrix
Character Set: 64- or 96-character (optional) EBCDIC or ASCII
Character Generation: ROM
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: Underline

Communications

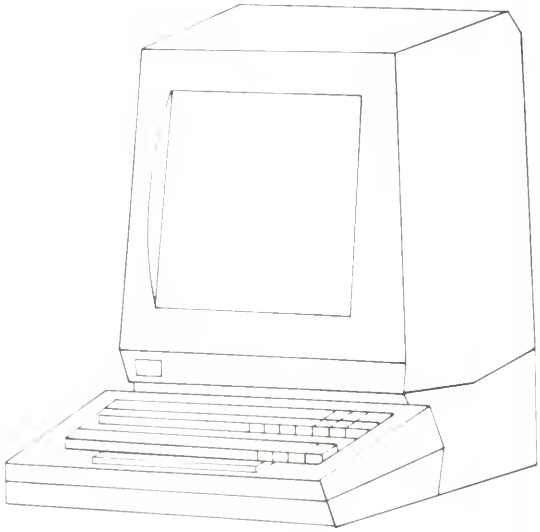
Interface: RS-232 C
Maximum Transmission Rate: 9600 baud, asynchronous
Mode: Half duplex
Parity: CRC check
Transmission Mode: Block

Options

Printer—275 cps
Light pen

MANUFACTURER
Conrac

MODEL
480/25



CHARACTERISTICS

Keyboard

Display

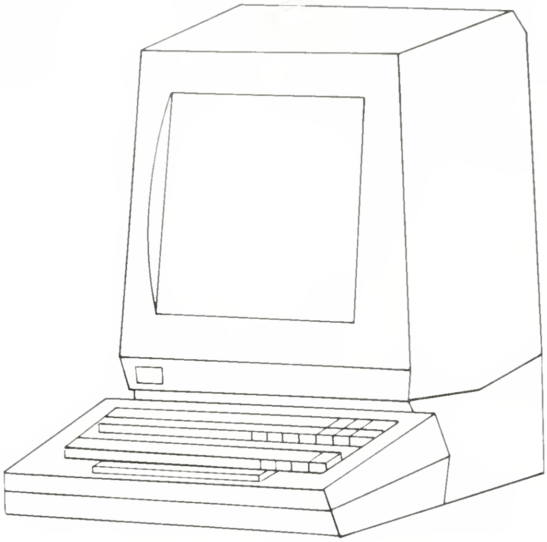
Format: 25 lines x 80 characters
Size: 7″ x 9″ usable
Character Type: Dot matrix
Character Set: 128-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 bps synchronous/asynchronous
Mode: Half or full duplex
Parity:
Transmission Mode: Data or full screen

MANUFACTURER
Control Data Corp.

MODEL
OEM 92451/92452



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 8″ x 5¼″
Character Type: 7 x 9 dot matrix
Character Set: 128-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

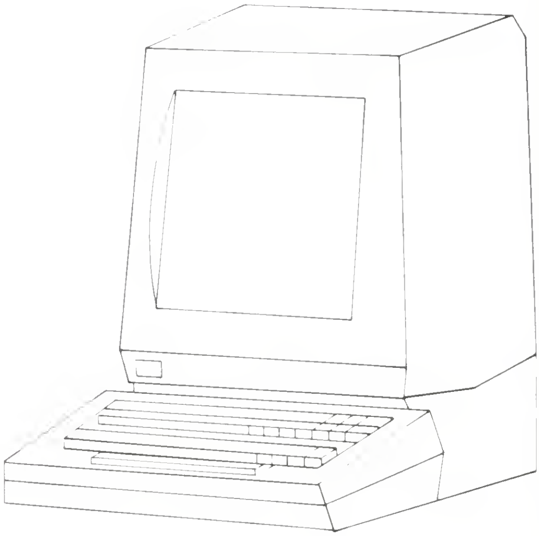
Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 bps asynchronous, switch selectable
Mode: Half or full duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Control Data Corp.

MODEL
711-10



CHARACTERISTICS

Keyboard

Display

Format: 16 lines x 80 characters
Size: 8″ x 10″
Character Type: Dot matrix
Character Set: 96-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

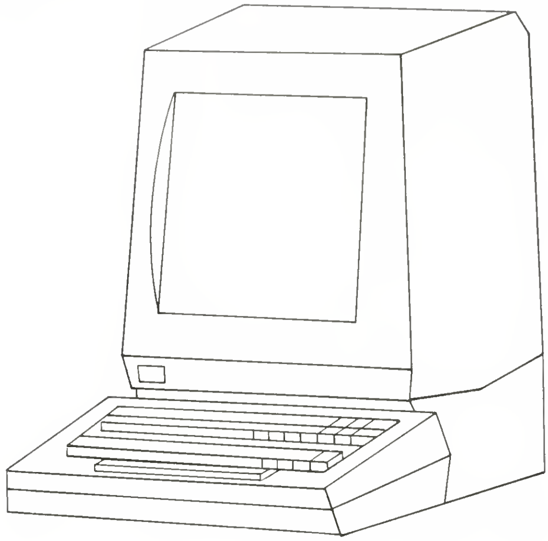
Communications

Interface: RS-232 C
Maximum Transmission Rate: 4800 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Control Data Corp.

MODEL
713–10 (TTY-compatible)



CHARACTERISTICS

Keyboard

Display

Format: 16 lines x 80 characters
Size: 8″ x 10″
Character Type: Dot matrix
Character Set: 96-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

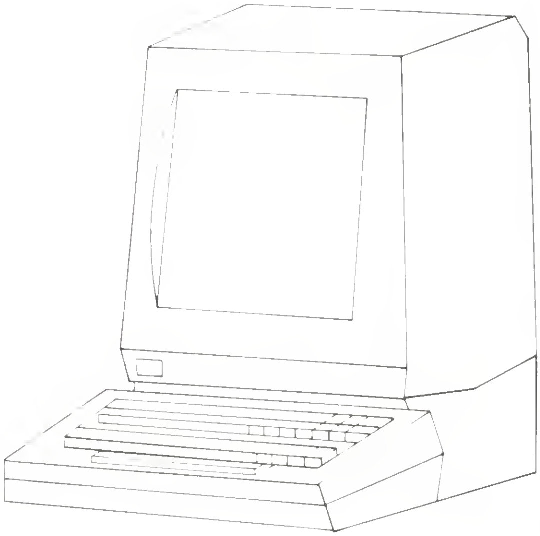
Communications

Interface: RS-232 C
Maximum Transmission Rate: 300 bps asynchronous
Mode: Half or full duplex
Parity:
Transmission Mode:

Options

MANUFACTURER
Control Data Corp.

MODEL
714



CHARACTERISTICS

Keyboard

Display

Format: 16 lines x 80 characters
Size: 8″ x 10″
Character Type: Dot matrix
Character Set: 96-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

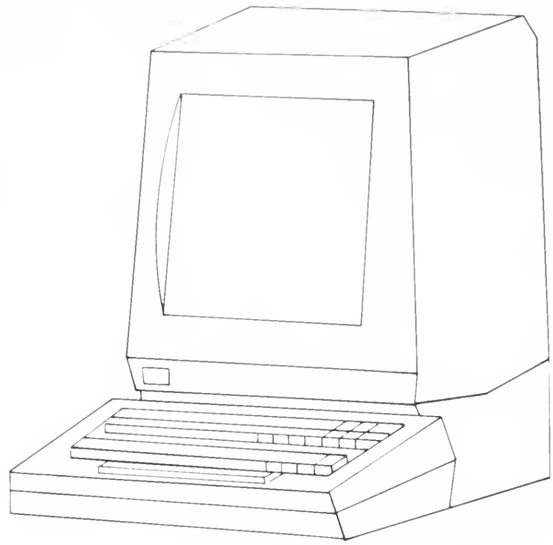
Communications

Interface: RS-232 C
Maximum Transmission Rate: 4800 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Courier Terminal Systems, Inc.

MODEL
270



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 10″ x 7″
Character Type: Dot matrix
Character Set: 96-character including lower case (optional)
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

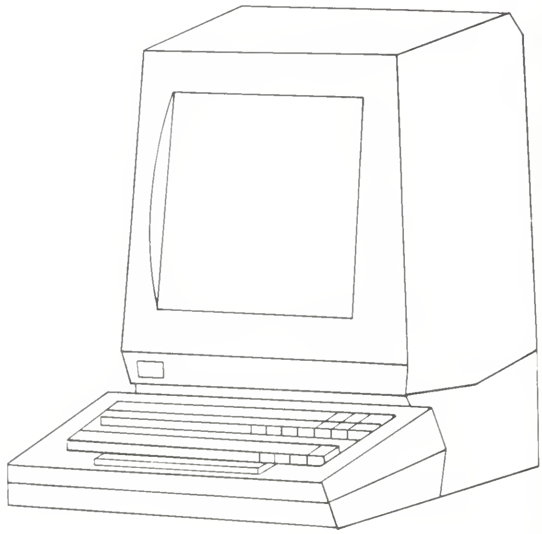
Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Data General Corp.

MODEL
6012



CHARACTERISTICS

Keyboard

Standard typewriter; numeric pad; function keys

Display

Format: 24 lines x 80 characters
Size: 7″ x 9″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character ASCII
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

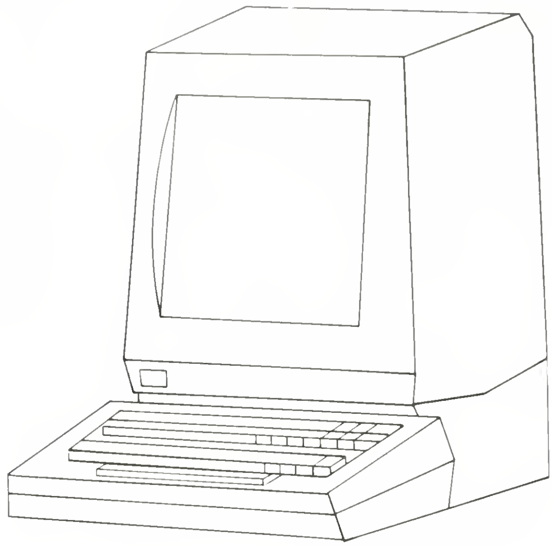
Communications

Interface: RS-232 C
Maximum Transmission Rate: 4800 baud
Mode: Half or full duplex
Parity:
Transmission Mode:

Options

MANUFACTURER
Datamedia

MODEL
Elite 1500 and 2500



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 6″ x 9″
Character Type: 5 x 7 dot matrix
Character Set: 128-character (optionally)
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move by CPU

Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 bps asynchronous
Mode: Half or full duplex
Parity:
Transmission Mode: Data or full screen
Format Mode:

Options

MANUFACTURER
Datapoint Corp.

MODEL
3300 Interactive Terminal

CHARACTERISTICS

Keyboard

Display

Format: 25 lines x 72 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64
Character Generation: Raster
Refresh Rate: 60
Refresh Memory: MOS
Cursor: Remote or local

Communications

Interface: RS-232 C
Transmission Rate: 2400 baud
Mode: Half or full duplex
Parity: Odd or even
Transmission Mode: Data or full screen

Options

MANUFACTURER
Datapoint Corp.

MODEL
Datastation 3600

CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 5″ x 7.9″
Character Type: 5 x 7 dot matrix
Character Set: 128
Character Generation: Raster
Refresh Rate: 50-60 Hz
Refresh Memory:
Cursor: CPU controlled

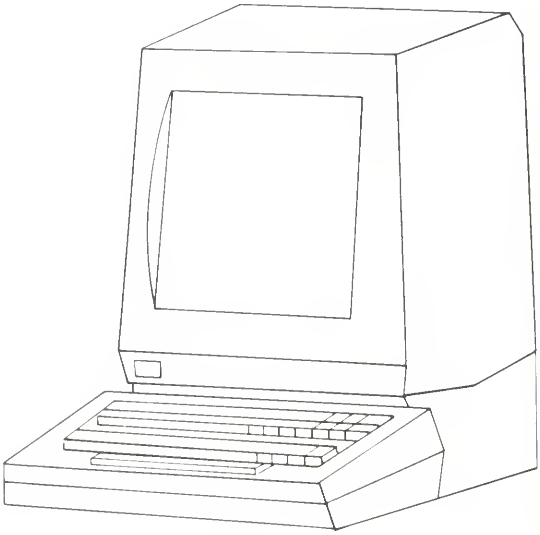
Communications

Interface: RS-232 C
Transmission Rate: 9600 baud (field adjustable)
Mode: Half or full duplex
Parity: Odd or even
Transmission Mode: Full screen

Options

MANUFACTURER
Delta Data Systems Corp.

MODEL
Delta 4000



CHARACTERISTICS

Keyboard

107 keys; ASCII; numeric pad; eight programmable function keys

Display

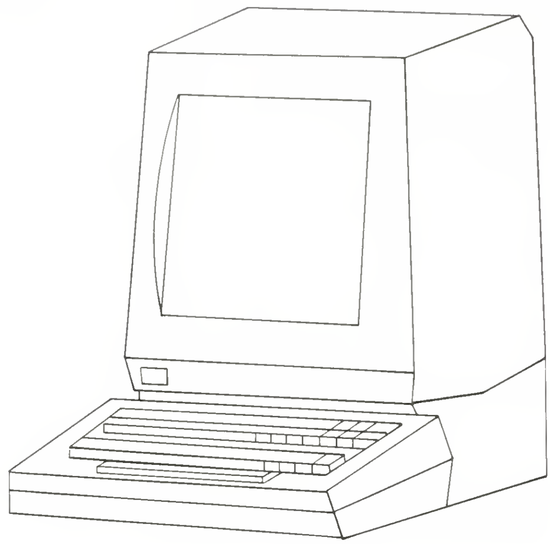
Format: 25 lines x 80 characters
Size: 14″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 224-character, displayable
Character Generation: MOS ROM
Refresh Rate: 60 Hz
Refresh Memory: MOS shift register
Cursor: Blinking underline, CPU "controlled"

Communications

Interface: RS–232 C or current loop
Maximum Transmission Rate: 9600 baud
Mode: Half duplex or echoplex
Parity: Switchable
Transmission Mode: Block or message

MANUFACTURER
Delta Data Systems Corp.

MODEL
Delta 5000/APL

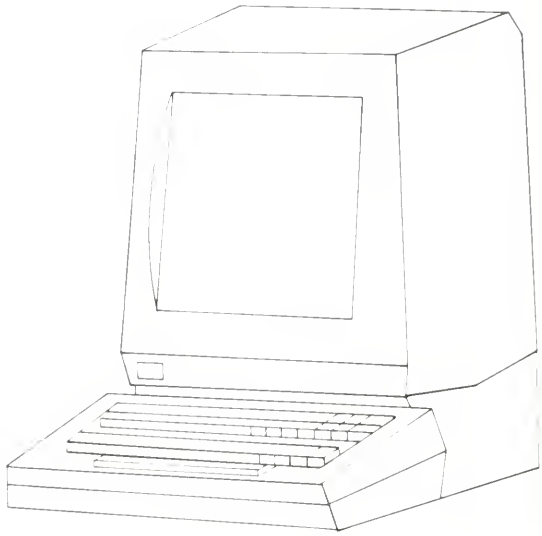


CHARACTERISTICS

Keyboard	APL bit paring
Display	*Format:* 27 lines x 80 characters *Size:* 7″ x 11″ *Character Type:* 7 x 9 dot matrix *Character Set:* Up to 128 characters *Character Generation:* *Refresh Rate:* *Refresh Memory:* *Cursor:*
Communications	*Interface:* RS-232 C, current loop, parallel *Maximum Transmission Rate:* 9600 baud, synchronous *Mode:* Half or full duplex *Parity:* *Transmission Mode:*
Options	ASCII upper and lower case

MANUFACTURER
Delta Data Systems Corp.

MODEL
5270

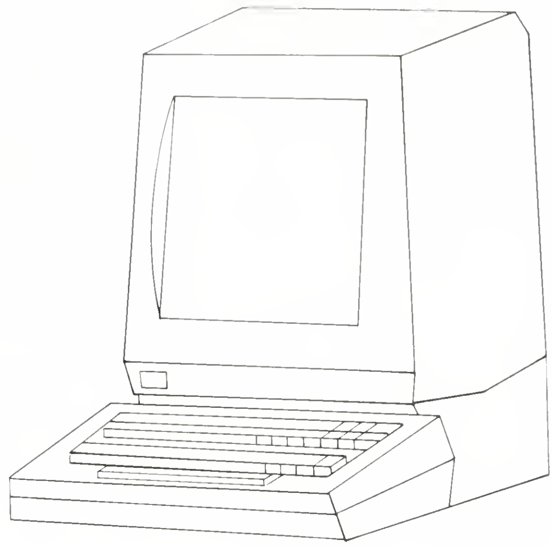


CHARACTERISTICS

Keyboard	TTY; 49 data keys; numeric pad; 28 control keys; light pen
Display	*Format:* 27 lines x 80 characters *Size:* 14″ CRT *Character Type:* 7 x 9 dot matrix *Character Set:* 64-character USASCII *Character Generation:* *Refresh Rate:* 60 Hz *Refresh Memory:* *Cursor:* Blinking underscore
Communications	*Interface:* RS-232 C/CCITT v.24 *Maximum Transmission Rate:* 9600 baud asynchronous *Mode:* Half or full duplex *Parity:* *Transmission Mode:* Message; memory
Options	96 characters, upper and lower case

MANUFACTURER
Delta Data Systems Corp.

MODEL
Delta 5500



CHARACTERISTICS

Keyboard	49 data keys, 10 key numeric pad, 28 control keys
Display	*Format:* 27 lines x 80 characters *Size:* 7″ x 11″ *Character Type:* 7 x 9 dot matrix *Character Set:* Up to 128-character displayable *Character Generation:* *Refresh Rate:* 60 Hz *Refresh Memory:* *Cursor:* Blinking underscore
Communications	*Interface:* RS-232 C/CCITT v.24 *Maximum Transmission Rate:* 9600 baud *Mode:* Half or full duplex *Parity:* *Character Mode:*
Options	96 characters—upper and lower case

MANUFACTURER
Digital Equipment Corp.

MODEL
VT-50

CHARACTERISTICS

Keyboard

Display

Format: 12 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character not including lower case
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: RAM
Cursor: Move by CPU, blinking underline

Communications

Interface: 20 ma current loop
Maximum Transmission Rate: 9600 baud
Mode: Half or full duplex
Parity: Odd, even, none
Transmission Mode: Character interactive

Options — RS–232 C interface

MANUFACTURER
Digital Equipment Corp.

MODEL
VT-52

CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 12″ CRT
Character Type: 7 x 7 dot matrix
Character Set: 128-character including lower case
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: RAM
Cursor: Move by CPU

Communications

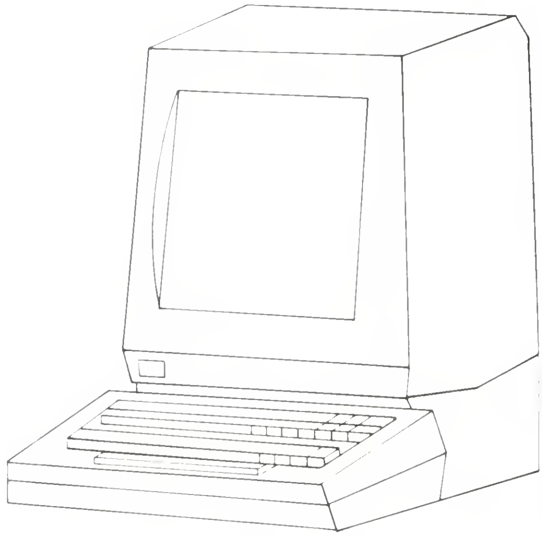
Interface: RS-232 C
Maximum Transmission Rate: 9600 bps asynchronous
Mode: Half or full duplex
Parity: Odd, even, none
Transmission Mode: Character interactive

Options

Printer interface

MANUFACTURER
Digi-Log Systems, Inc.

MODEL
Telecomputer II



CHARACTERISTICS

Keyboard

Display

Format: 16 lines x 40/80 characters
Size: Any video tube
Character Type: 5 x 7 dot matrix
Character Set: 64-character not including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move by CPU

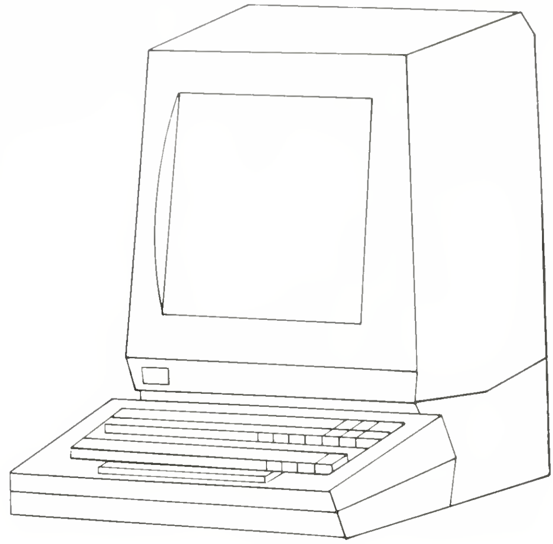
Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 bps asynchronous
Mode: Half or full duplex
Parity:
Transmission Mode:

Options

MANUFACTURER
Four-Phase Systems

MODEL
IV/40 and IV/70



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 7.25″ x 10.25″
Character Type: 7 x 9 dot matrix
Character Set: 125-character
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

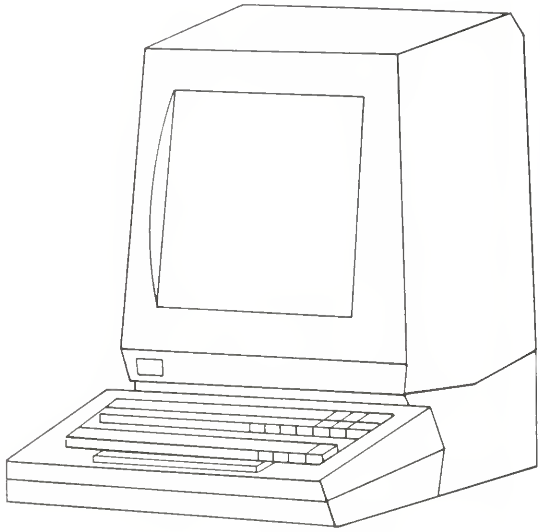
Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 baud
Mode: Half or full duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
GTE/IS

MODEL
IS/7000



CHARACTERISTICS

Keyboard

Display

Format: 15/12 lines x 12/80 characters
Size: 12″ CRT
Character Type: 5″ x 7″ dot matrix
Character Set: 64-characters, displayable, not including lower case
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Move/read by CPU

Communications

Interface: RS-232 C, IBM channel
Maximum Transmission Rate: 9600 bps asynchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Genesis One Computer Corp.

MODEL
G77

CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 7″ x 10″
Character Type: 5 x 7 dot matrix
Character Set: 95-character including lower case
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Move/read by CPU, blinking

Communications

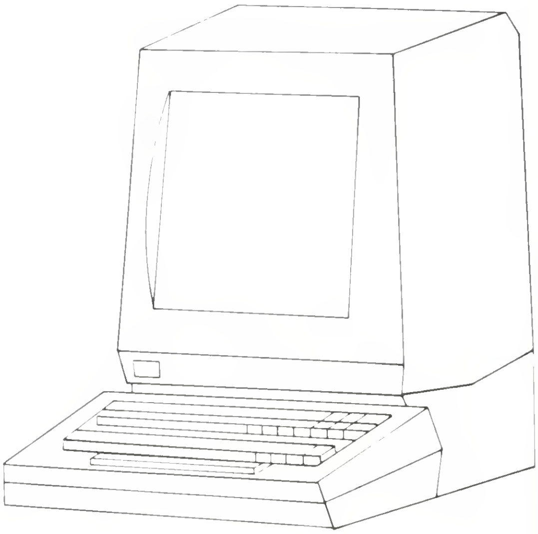
Interface:
Maximum Transmission Rate: 7200 bps synchronous
Mode:
Parity:
Transmission Mode: Data or full screen

Options

Light pen
15-Key numeric pad

MANUFACTURER
Goodwood Data Systems Ltd.

MODEL
GDS 300



CHARACTERISTICS

Keyboard

Display

Format: 12/24 lines x 40/80 characters
Size:
Character Type: 5 x 7 dot matrix
Character Set: 64-character USASCII
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Communications

Interface: RS-232 C HDX/FDX
Maximum Transmission Rate:
Mode:
Parity:
Transmission Mode:

Options

96 or 128-character set
Split screen
16-button keypack

MANUFACTURER
Hazeltine Corp.

MODEL
Modular One

CHARACTERISTICS

Keyboard — Numeric pad; function pad

Display

Format: 24 lines x 80 characters
Size: 12″ CRT
Character Type: 7 x 9 dot matrix
Character Set:
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Block or blinking underscore

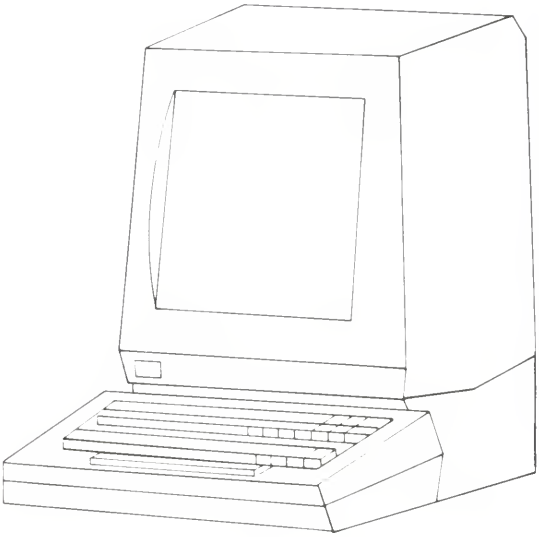
Communications

Interface: RS-232 C, current loop, switch selectable
Maximum Transmission Rate: 9600 baud
Mode:
Parity:
Transmission Mode:

Options — Polling option provided for user-defined protocol for communication network interface

MANUFACTURER
Hazeltine Corp.

MODEL
Hazeltine 1200



CHARACTERISTICS

Keyboard

Teletypewriter key format for alphanumerics; switch cluster for operational mode

Display

Format: 24 lines x 80 characters
Size: Height: 12″; Width: 15″; Length: 20″
Character Type: 5 x 7 upper case dot matrix (lower case optional)
Character Set: 64-character displayable alphanumerics and symbols
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory: MOS shift register with constant refresh
Cursor:

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 baud asynchronous

Mode: Half and full duplex
Parity: Odd, even, none (switch selectable)
Transmission Mode:

Options

MANUFACTURER
Hazeltine Corp.

MODEL
2000

CHARACTERISTICS

Keyboard — TTY-compatible; 10-key numeric plus editing and cursor control

Display

Format: 27 lines x 74 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character alphanumeric and symbol; 32-character ASCII control codes
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Nonblinking underscore

Communications

Interface: RS-232 B/C
Maximum Transmission Rate: 9600 baud synchronous
Mode: Half or full duplex
Parity: Odd or even (switch selectable)
Transmission Mode:

Options — 25 lines x 80 characters, nonstandard baud rates

MANUFACTURER
Honeywell

MODEL
VIP Series 7700

CHARACTERISTICS

Keyboard

86 keys; numeric pad; 58 function codes

Display

Format: 12/24 lines x 80 characters
Size: 8.5″ x 5.5″
Character Type: 7 x 9 dot matrix
Character Set: 63- or 94-character including lower case
Character Generation: ROM
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: Move by CPU or keyboard; block, blinking

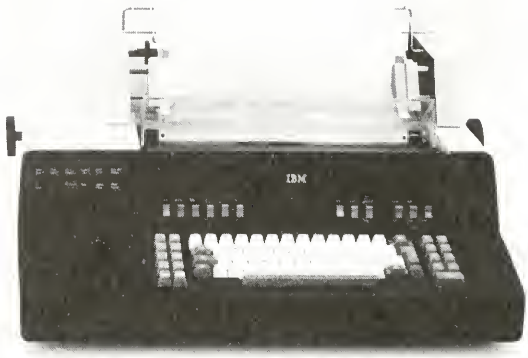
Communications

Interface: RS-232 C
Maximum Transmission Rate: 4800 bps synchronous
Mode: Half or full duplex
Parity: Odd character, even block
Transmission Mode: Data or full screen

Options

MANUFACTURER
IBM

MODEL
3277 Models 1 and 2

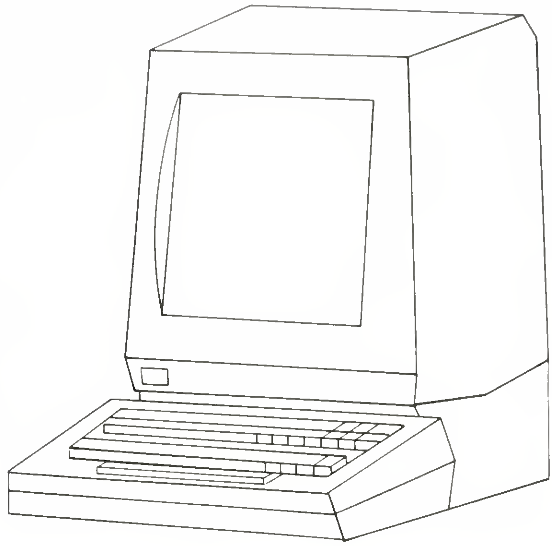


CHARACTERISTICS

Keyboard	ASCII or EBCDIC, 66- and 78-key versions including function keys
Display	*Format:* 1–12 lines x 40 characters 2–24 lines x 80 characters *Size:* 9″ or 15″ CRT *Character Type:* *Character Set:* 63 or 96 *Character Generation:* *Refresh Rate:* 50 Hz *Refresh Memory:* *Cursor:* Underscore
Communications	*Interface:* RS-232 C or local channel attachment *Maximum Transmission Rate:* 9600 bps bi-synchronous; 650 Kb channel *Mode:* Half duplex *Parity:* *Transmission Mode:* Full screen
Options	Text processing Character set APL character set

MANUFACTURER
ITT

MODEL
3100 Alphascope



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 6″ x 9″
Character Type: Dot matrix
Character Set: 67-character upper case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

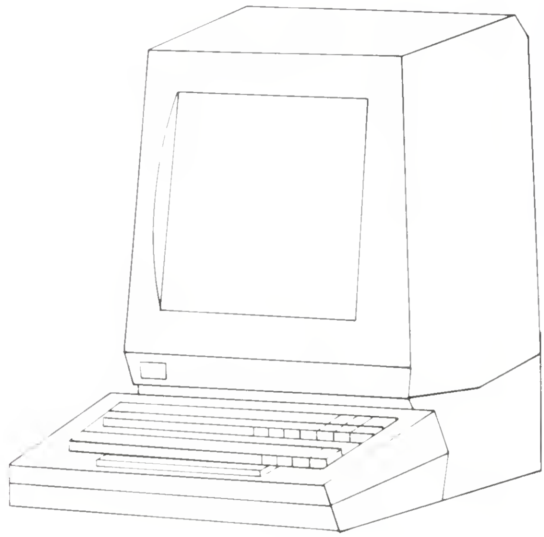
Communications

Interface: RS-232 C
Maximum Transmission Rate: 4800 bps synchronous/asynchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
ITT

MODEL
3501 ASCIscope



CHARACTERISTICS

Keyboard

Display

Format: 12 lines x 80 characters
Size: 8″ x 5″
Character Type: Dot matrix
Character Set: 64-character not including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move by CPU

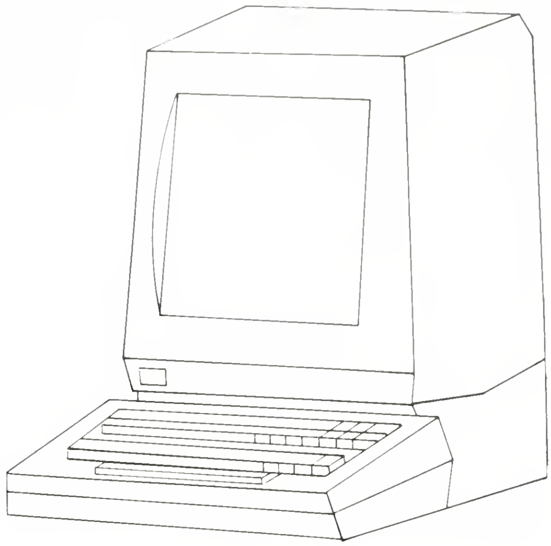
Communications

Interface: RS-232 C
Maximum Transmission Rate: 2400 bps synchronous/asynchronous
Mode: Half or full duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Informer, Inc.

MODEL
D301/302

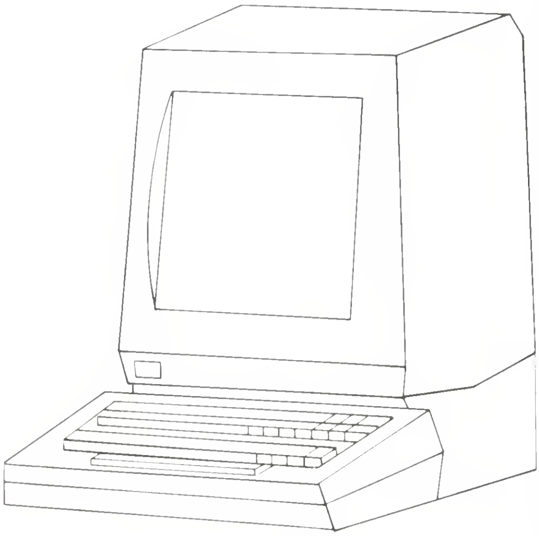


CHARACTERISTICS

Keyboard	Alphanumeric set and numeric pad, 10 function keys, 70 total keys.
Display	*Format:* 32 lines x 60 characters *Size:* 6″ CRT *Character Type:* Dot matrix *Character Set:* Full ASCII *Character Generation:* MOS *Refresh Rate:* 60 Hz *Refresh Memory:* RAM *Cursor:* CPU-controlled
Communications	*Interface:* RS–232 C or current loop *Maximum Transmission Rate:* 9600 baud *Mode:* Half or full duplex *Parity:* Any *Transmission Mode:* Character & block

MANUFACTURER
Infoton, Inc.

MODEL
Vistar



CHARACTERISTICS

Keyboard — ASCII; numeric pad

Display

Format: 24 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character
Character Generation: MOS
Refresh Rate: 50/60 Hz
Refresh Memory: MOS
Cursor: Blinking underscore

Communications

Interface: RS-232 C current loop
Maximum Transmission Rate: 9600 baud
Mode: Half or full duplex
Parity: Odd, even, mark
Transmission Mode: Data or full screen, block/character

Options

MANUFACTURER
Infoton, Inc.

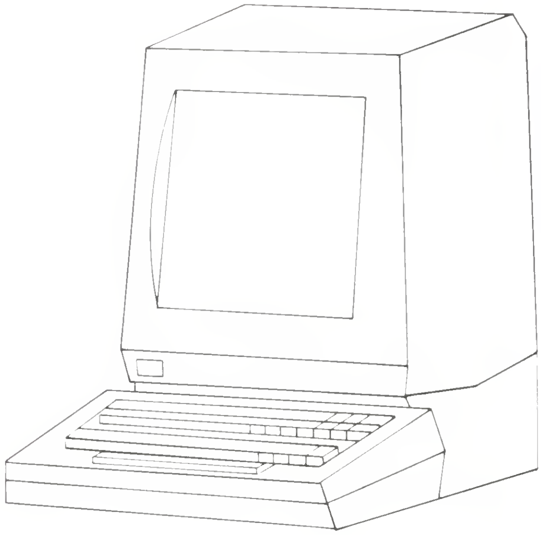
MODEL
Vistar/Satellite

CHARACTERISTICS

Keyboard	ASCII; numeric pad, function keys
Display	*Format:* 24 lines x 80 characters *Size:* 12″ CRT *Character Type:* 5 x 7 dot matrix *Character Set:* 128-character upper and lower case *Character Generation:* MOS *Refresh Rate:* 50/60 Hz *Refresh Memory:* MOS *Cursor:* Blinking underscore cursor address
Communications	*Interface:* RS-232 C and current loop *Maximum Transmission Rate:* 9600 baud *Mode:* Half or full duplex *Parity:* Odd, even, mark *Transmission Mode:* Block/character
Options	

MANUFACTURER
Infoton, Inc.

MODEL
Vistar/GTX



CHARACTERISTICS

Keyboard

ASCII

Display

Format: 24 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64
Character Generation: MOS
Refresh Rate: 50/60 Hz
Refresh Memory: MOS
Cursor: Blinking underscore

Communications

Interface: RS-232 C and current loop
Transmission Rate: 9600
Mode: Half or full duplex
Parity: Odd, even, mark
Transmission Mode: Character

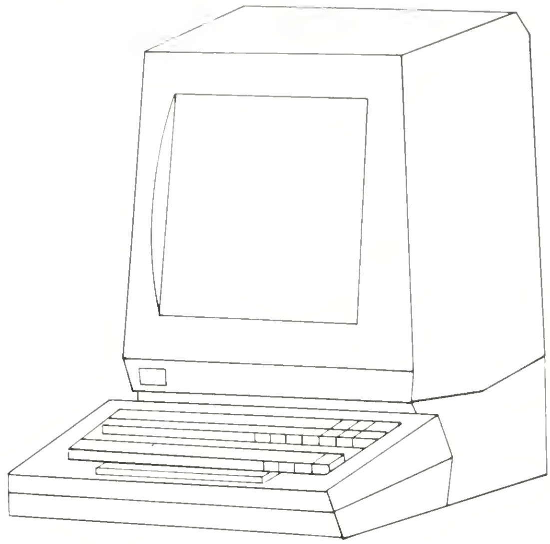
Options

MANUFACTURER

International Communications Corp.

MODEL

40+



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 5.5″ x 10.75″
Character Type: 7 x 11 dot matrix
Character Set: 127-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move by CPU

Communications

Interface: RS-232 C
Maximum Transmission Rate: 2400 bps synchronous/asynchronous (selectable)
Mode: Half or full duplex
Parity:
Transmission Mode: Data or full screen

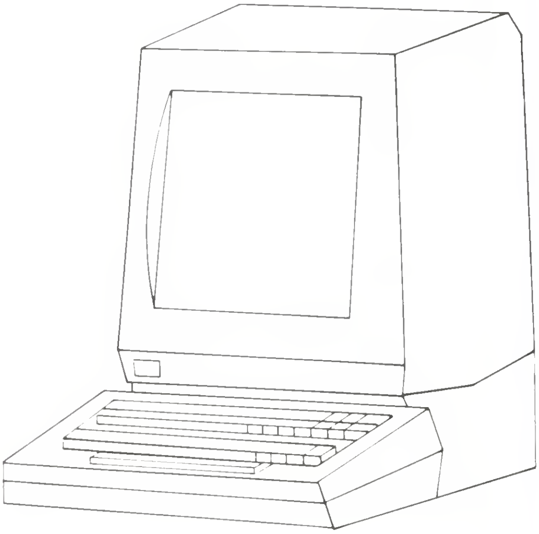
Options

MANUFACTURER

Kustom Data Communications, Inc.

MODEL

MCT 10



CHARACTERISTICS

Keyboard

Display

Format: 7 lines x 32 characters
Size: 3.38″ x 9.18″
Character Type: Dot matrix
Character Set:
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

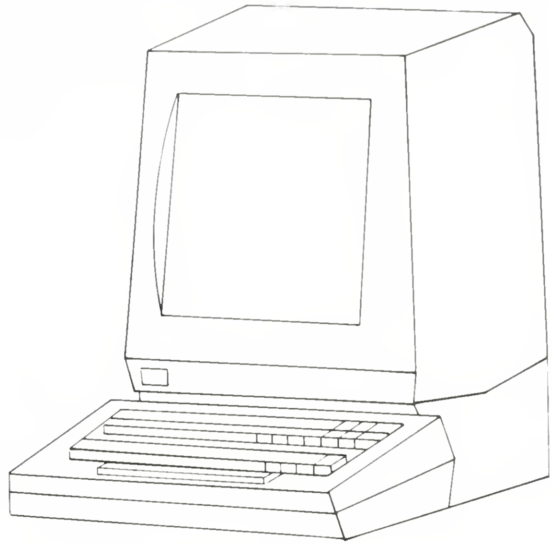
Communications

Interface: Radio
Maximum Transmission Rate: 1300 bps synchronous
Mode: Half or full duplex
Parity:
Transmission Mode: Data only

Options

MANUFACTURER
Lear-Siegler, Inc.

MODEL
ADM-1



CHARACTERISTICS

Keyboard	60-key TTY standard
Display	*Format:* 12 lines x 80 characters *Size:* 12″ CRT *Character Type:* 5 x 7 dot matrix *Character Set:* 64-character alphanumeric ASCII *Character Generation:* *Refresh Rate:* 60 Hz *Refresh Memory:* *Cursor:* Reverse image, block cursor
Communications	*Interface:* RS-232 C point-to-point *Maximum Transmission Rate:* 9600 baud *Mode:* Half or full duplex *Parity:* Odd, even, one, or zero *Transmission Mode:* Transmission; text only
Options	10-key numeric pad 24 lines x 80 character Editing Beep Polling addressing

MANUFACTURER
Lear-Siegler, Inc.

MODEL
ADM-2 Executive

CHARACTERISTICS

Keyboard

119 key unit; 63 alphanumeric keys; 10-key numeric pad; 16 function keys, including cursor control and 4 transmission control keys.

Display

Format: 24 lines x 80 characters
Size: 9″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 128-character ASCII
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Moved by CPU; underscore

Communications

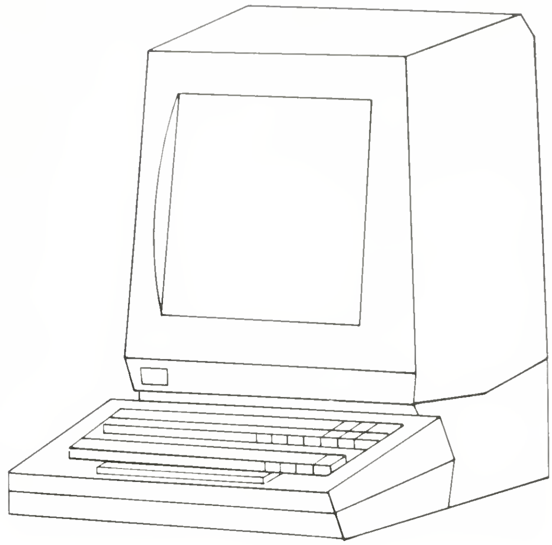
Interface: RS-232 C
Maximum Transmission Rate: 19,200 bps, asynchronous
Mode: Half and full duplex
Parity:
Transmission Mode:

Options

5 x 9 dot matrix

MANUFACTURER
Lektromedia

MODEL
LEK 104



CHARACTERISTICS

Keyboard — ASCII upper and lower case

Display

Format: 24 lines x 80 characters; 640 x 240 dot-plotting matrix
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 128-character ASCII
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Communications

Interface: RS-232 C
Maximum Transmission Rate:
Mode: Half or full duplex, asynchronous
Parity: Switchable
Transmission Mode:

Options

MANUFACTURER
Lektromedia

MODEL
LEK 104 Graphics Terminal

CHARACTERISTICS

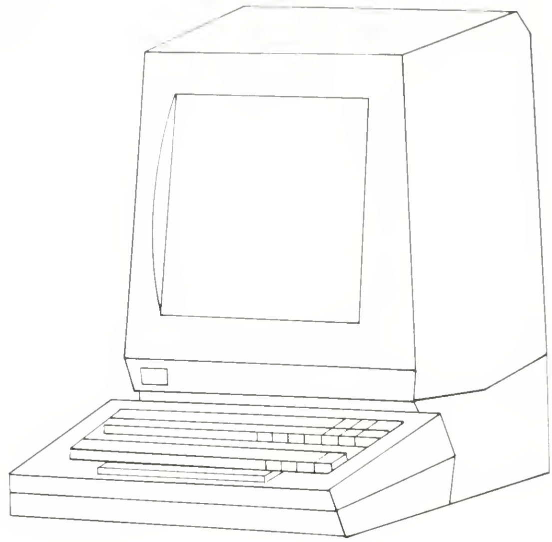
Keyboard	128-character ASCII upper and lower case
Display	*Format:* 24 lines x 80 characters *Size:* 12″ CRT *Character Type:* 5 x 7 dot matrix *Character Set:* 128-character ASCII *Character Generation:* *Refresh Rate:* *Refresh Memory:* *Cursor:* Controlled from keyboard
Communications	*Interface:* RS-232 C *Maximum Transmission Rate:* *Mode:* Half or full duplex, asynchronous *Parity:* Switchable *Transmission Mode:*
Options	Keyboard with tactile feedback

MANUFACTURER

Megadata Computer and Communications Corp.

MODEL

SIR 1000 Powerscope



CHARACTERISTICS

Keyboard

Display

Format: 24/27 lines x 80 characters
Size: 15″ CRT
Character Type: Up to 12 x 23 dot matrix
Character Set: 292-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

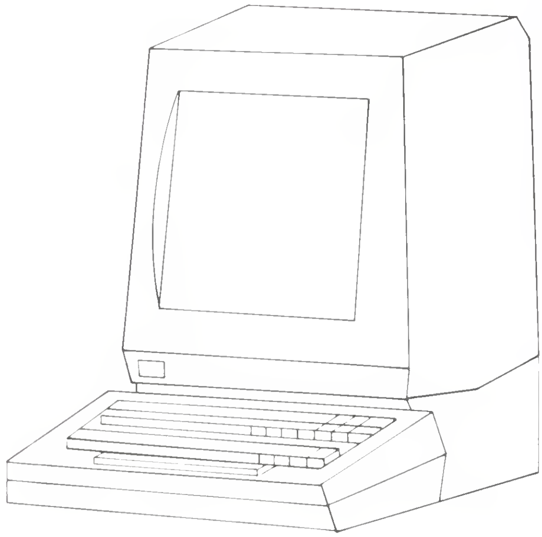
Communications

Interface: RS-232 C, loop, parallel
Maximum Transmission Rate: 300,000 bps/9600 bps synchronous
Mode: Half or full duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Micro Application Systems

MODEL
T1



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 96-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

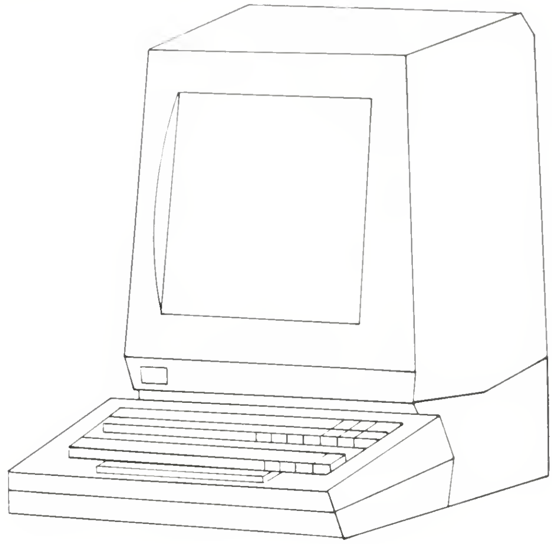
Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 bps asynchronous
Mode: Half and full duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Olivetti

MODEL
DSY 8060



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 15″ CRT
Character Type: 9 x 9 dot matrix
Character Set: 96- or 128-character upper and lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Underscore

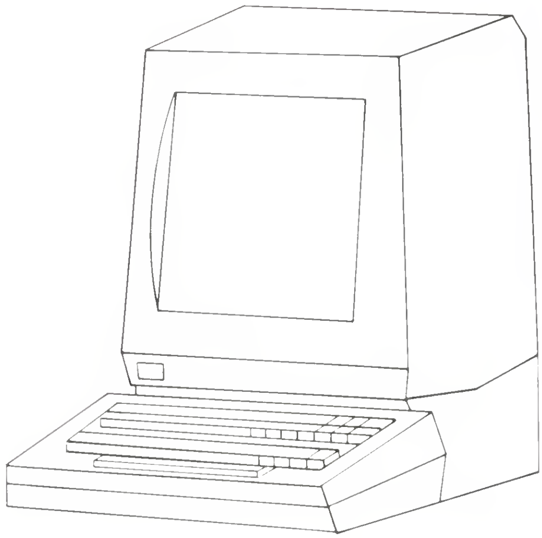
Communications

Interface:
Maximum Transmission Rate:
Mode:
Parity:
Transmission Mode:

Options

MANUFACTURER
Pertec Business Systems

MODEL
700



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 5.5″ x 8.25″
Character Type: 7 x 9 dot matrix
Character Set: 64/96-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Read by CPU

Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 bps synchronous/asynchronous (switch selectable)
Mode: Half and full duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Princeton Electronic
Products, Inc.

MODEL
801

CHARACTERISTICS

Keyboard — 128-character ASCII

Display

Format: Up to 43 lines x 83 characters
Size: 10″ x 10″
Character Type:
Character Set:
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Communications

Interface:
Maximum Transmission Rate: 2400 baud
Mode: Half or full duplex
Parity:
Transmission Mode:

Options

MANUFACTURER
Research, Inc.

MODEL
Teleray Series 3300

CHARACTERISTICS

Keyboard

TTY, 53 Keys

Display

Format: 24 lines x 40/80 characters
Size: 6.5″ x 8.5″
Character Type: 5 x 7 dot matrix
Character Set: 96-character generated, 64-character displayed
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Solid underscore

Communications

Interface: RS-232 C, current loop, TTL (selectable)
Maximum Transmission Rate: 2400 baud
Mode: Half or full duplex
Parity: Odd, even, high, low
Transmission Mode:

Options	Composite video output (RS-170) Peripheral interface Numeric keypad Detached keyboard 50 Hz

MANUFACTURER
Research, Inc.

MODEL
Teleray Series 3500

CHARACTERISTICS

Keyboard

TTY, 53 keys, upper case, numeric key pad

Display

Format: 24 lines x 40/80 characters
Size: 6.5″ x 8.5″
Character Type: 5 x 7 dot matrix
Character Set: 96-character generated, 64-character displayed
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Solid underscore

Communications

Interface: RS-232 C, current loop, TTL
Maximum Transmission Rate: 9600 baud
Mode: Half or full duplex
Parity: Odd, even, high, low
Transmission Mode: Character-by-character

Options	Composite video output (RS-170)
	Peripheral interface
	Numeric keypad
	Detached keyboard
	50 Hz
	15″ CRT
	Incremental horizontal tab

MANUFACTURER
Research, Inc.

MODEL
Teleray Series 3700

CHARACTERISTICS

Keyboard

62 keys, typewriter style

Display

Format: 24 lines x 40/80 characters
Size: 6.5″ x 8.5″
Character Type: 5 x 9 dot matrix
Character Set: 128-character generated, 95-character displayed
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Solid underscore

Communications

Interface: RS-232 C, current loop, TTL
Maximum Transmission Rate: 9600 baud
Mode: Half or full duplex
Parity: Odd, even, high, low
Transmission Mode:

Options	Composite video output (RS-170)
	Peripheral interface
	Numeric keypad
	Detached keyboard
	50 Hz
	15″ CRT
	Incremental horizontal tab

MANUFACTURER
Scientific Measurement Systems, Inc.

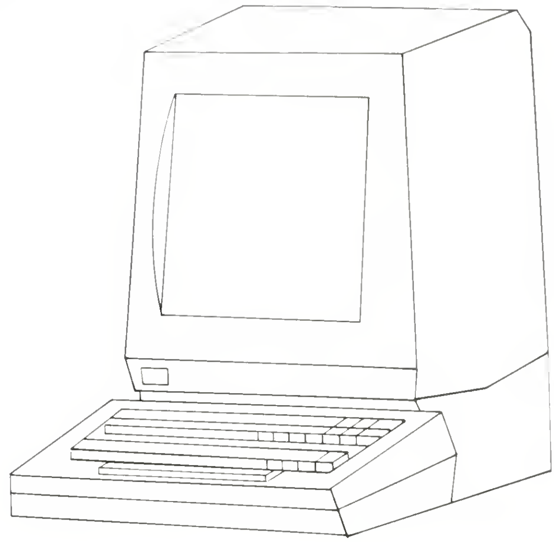
MODEL
SMS 1920

CHARACTERISTICS

Keyboard	Standard ASCII; 2 key rollover
Display	*Format:* 24 lines x 80 characters *Size:* 6″ x 10″ *Character Type:* 5 x 7 dot matrix *Character Set:* 95-character including lower case *Character Generation:* *Refresh Rate:* 60 Hz *Refresh Memory:* *Cursor:* Read/moved by CPU
Communications	*Interface:* RS-232 C, current loop *Maximum Transmission Rate:* 19,200 asynchronous (switch selectable) *Mode:* Half and full duplex *Parity:* *Transmission Mode:* Data or full screen
Options	Upper and lower case 50 Hz refresh rate

MANUFACTURER
TEC, Inc.

MODEL
Series 400 (11 models)

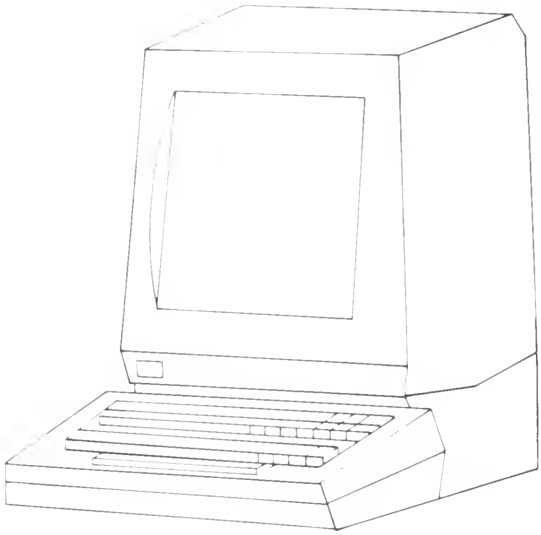


CHARACTERISTICS

Keyboard	68 keys (typically); function keys; detachable pad
Display	*Format:* 20 lines x 50 characters to 24 lines x 80 characters *Size:* 12″ CRT *Character Type:* *Character Set:* *Character Generation:* *Refresh Rate:* *Refresh Memory:* *Cursor:*
Communications	*Interface:* RS-232 C, TTL, current loop *Maximum Transmission Rate:* 9600 baud *Mode:* *Parity:* *Transmission Mode:*
Options	15-key numeric pad Printer

MANUFACTURER
TEC, Inc.

MODEL
Mini-TEC 1400 and 2400



CHARACTERISTICS

Keyboard

64-character ASCII alphanumeric; function keys; 15-key numeric pad

Display

Format: 12 lines x 80 characters (1400); 24 lines x 80 characters (2400)
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character ASCII
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Blinking underscore

Communications

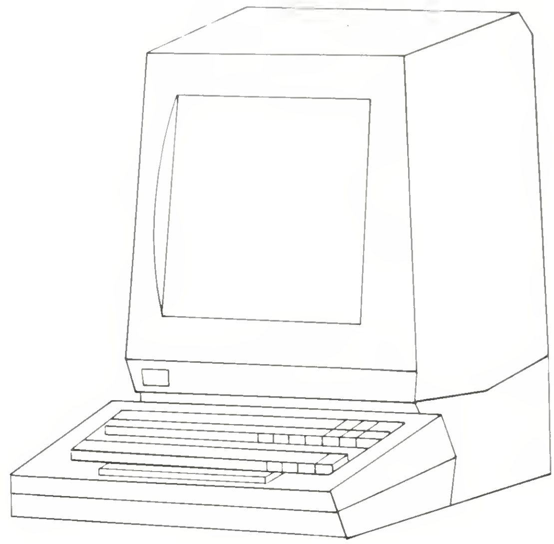
Interface: RS-232 C, TTL or current loop
Maximum Transmission Rate: 9600 baud (switch selectable)
Mode: Half or full duplex
Parity: Odd, even, or none
Transmission Mode: Character; block (line or page)

Options

128 characters; upper and lower case

MANUFACTURER
TEC, Inc.

MODEL
Tele-Tec 1440



CHARACTERISTICS

Keyboard

95-character ASCII with symbols; 10 function keys

Display

Format: 24 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character ASCII
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Blinking underscore

Communications

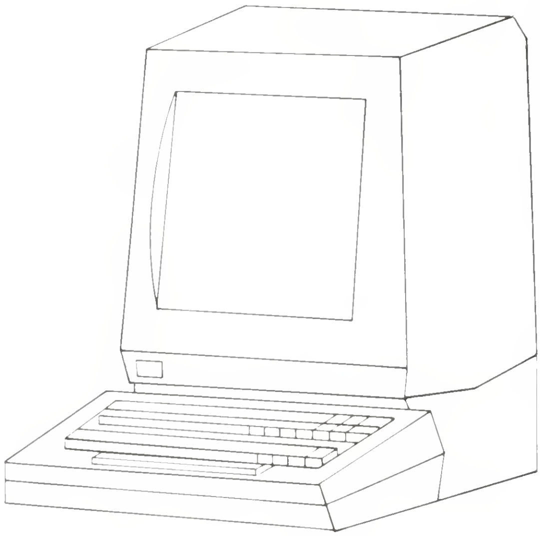
Interface: TTL or current loop
Maximum Transmission Rate: 9600 baud, switch selectable
Mode: Half or full duplex; conversational
Parity: Odd, even, or none
Transmission Mode:

Options

RS-232 C interface

MANUFACTURER
Tektronix, Inc.

MODEL
Tektronix 4006-1



CHARACTERISTICS

Keyboard

Display

Format: 35 lines x 74 characters
Size: 7.5″ x 5.6″
Character Type: 5 x 7 dot matrix
Character Set: 63-character displayable
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

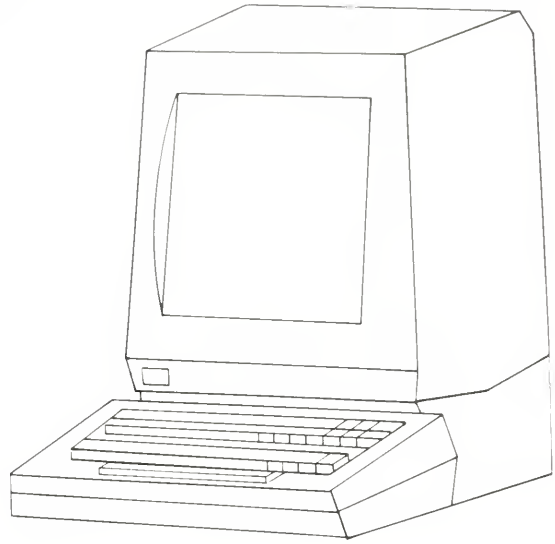
Communications

Interface:
Maximum Transmission Rate:
Mode:
Parity:
Transmission Mode:

Options

MANUFACTURER
Tektronix, Inc.

MODEL
Tektronix 4023

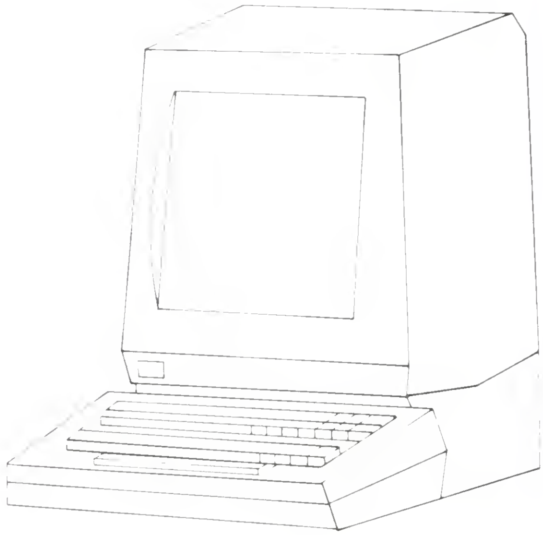


CHARACTERISTICS

Keyboard	64/96-character ASCII
Display	*Format:* 24 lines x 80 characters *Size:* 8.5″ x 4.5″ *Character Type:* 5 x 7 dot matrix *Character Set:* *Character Generation:* *Refresh Rate:* 60 Hz *Refresh Memory:* MOS RAM *Cursor:*
Communications	*Interface:* RS-232 C *Maximum Transmission Rate:* Up to 9600 baud (switch selectable) *Mode:* *Parity:* *Transmission Mode:*
Options	Data communications interface Hard copy unit Digital cartridge tape recorder

MANUFACTURER
Tektronix, Inc.

MODEL
Textronix 4051

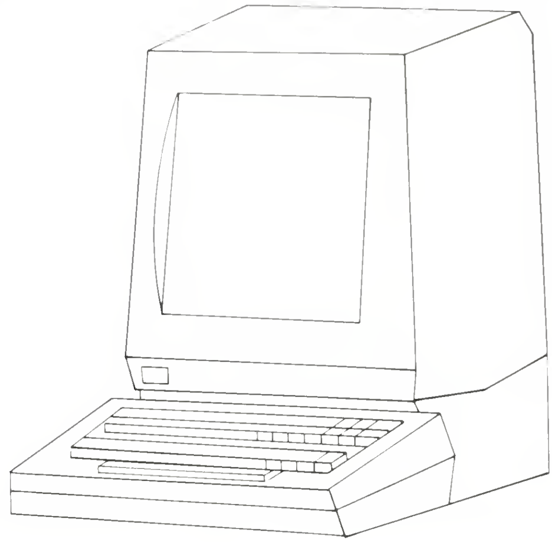


CHARACTERISTICS

Keyboard	Full ASCII, 128 characters
Display	
	Format: 35 lines x 72 characters *Character Type:* *Character Set:* Full ASCII character set *Character Generation:* *Refresh Rate:* *Refresh Memory:* *Cursor:*
Communications	
	Interface: *Maximum Transmission Rate:* *Mode:* *Parity:* *Transmission Mode:*
Options	

MANUFACTURER
Teleram Communications Corp.

MODEL
P-1800



CHARACTERISTICS

Keyboard

91 keys

Display

Format: 14 lines x 44 characters
Size: 6.6″ x 4.5″
Character Type: 7 x 9 dot matrix
Character Set: 127-character including lower case
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Manual—4 directions

Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 8600 (switch selectable)
Mode: Half duplex
Parity: Odd, even, none
Transmission Mode: Full screen

Options

MANUFACTURER
Teletype Corp.

MODEL
Model 40

CHARACTERISTICS

Keyboard — ASCII 101 or 127 characters and controls

Display

Format: 24 lines x 80 characters
Size: 13″ CRT
Character Type: 7 x 9 dot matrix
Character Set: 127-character ASCII
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: Constant image

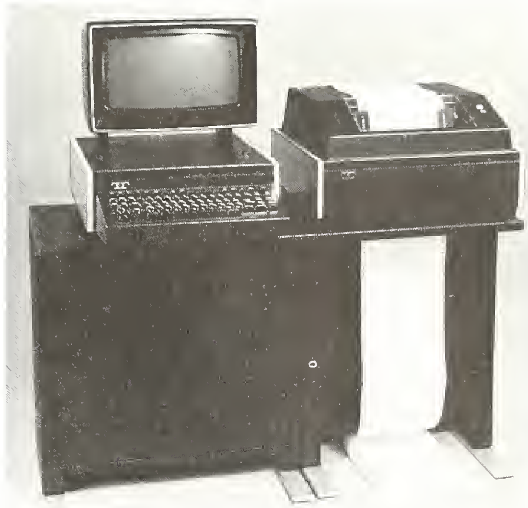
Communications

Interface: RS-232 C
Maximum Transmission Rate: 120 cps
Mode: Half duplex
Parity: Even
Transmission Mode: Serial by bit or character

Options — Page printer 300 lpm

MANUFACTURER
Teletype Corp.

MODEL
40/1



CHARACTERISTICS

Keyboard
127-character ASCII (typical)

Display

Format: 24 lines x 80 characters
Size: 13″ CRT
Character Type: 7 x 9 dot matrix
Character Set: 96-character ASCII
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: Constant image

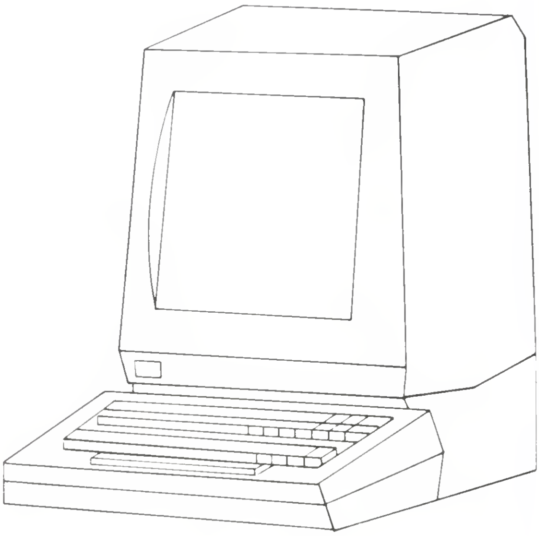
Communications

Interface: RS-232 C
Maximum Transmission Rate: 1200 bps
Mode: Half
Parity: Even
Transmission Mode: Block

Options
Various combinations of keyboard-display-printer
Other transmission rates

MANUFACTURER
Teletype Corp.

MODEL
40/2



CHARACTERISTICS

Keyboard — 94-character ASCII

Display

Format: 24 lines x 80 characters
Size:
Character Type: 7 x 9 dot matrix
Character Set: 127-character and symbols
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: Character-size

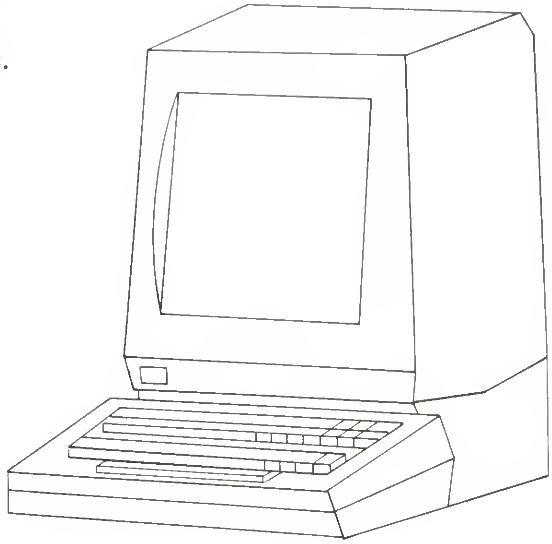
Communications

Interface: RS-232 C or current loop
Maximum Transmission Rate: up to 4800 bps (installer-set)
Mode: Half or full duplex
Parity: Odd or even
Transmission Mode: Character or block

Options

MANUFACTURER
Terminal Communications, Inc.

MODEL
TC-275



CHARACTERISTICS

Keyboard

Display

Format: 40 lines x 80 characters or 12 lines x 24 characters
Size: 14″ CRT
Character Type: 7 x 9 dot matrix
Character Set: 128-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

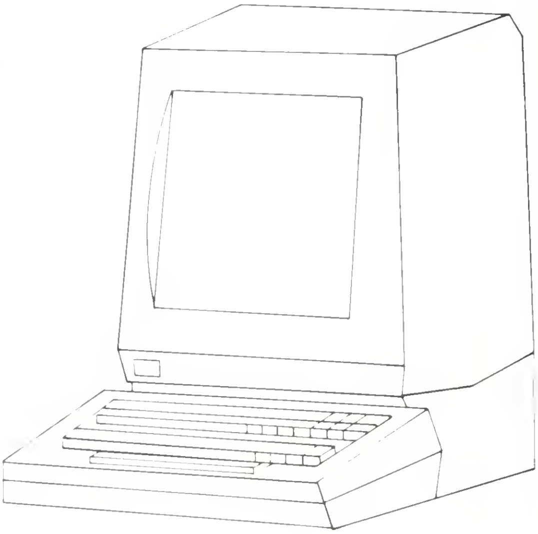
Communications

Interface: RS-232 C
Maximum Transmission Rate: 4800 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Terminal Communications, Inc.

MODEL
TC-277



CHARACTERISTICS

Keyboard

Display

Format: 40 lines x 80 characters or 12 lines x 24 characters
Size: 14″ CRT
Character Type: 7 x 9 dot matrix
Character Set: 128-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

Communications

Interface: RS-232 C
Maximum Transmission Rate: 7200 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Texas Instruments, Inc.

MODEL
913

CHARACTERISTICS

Keyboard

Display

Format: 12 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set:
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 baud
Mode:
Parity:
Transmission Mode:

Options

MANUFACTURER
Texas Instruments, Inc.

MODEL
914A Video Terminal

CHARACTERISTICS

Keyboard

105 keys; separate numeric pad repeating keys; ASCII-B

Display

Format: 24 lines x 80 characters
Size: 14″ CRT
Character Type: 7 x 9 dot matrix
Character Set:
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Key control; underscore

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 baud selectable
Mode:
Parity:
Transmission Mode:

Options

MANUFACTURER
Trivex, Inc.

MODEL
Plus 70

CHARACTERISTICS

Keyboard

Typewriter, data entry console

Display

Format: 24 lines x 80 characters
Size: 10″ x 8″
Character Type: 7 x 9 dot matrix
Character Set: 96-character EBCDIC
Character Generation: PROM
Refresh Rate: 60 Hz
Refresh Memory: RAM
Cursor: Buffer position

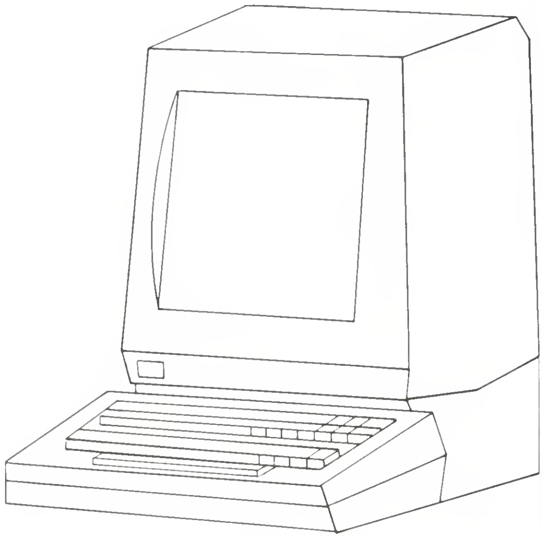
Communications

Interface: RS-232 C, IBM channel
Maximum Transmission Rate: 9600 bps synchronous (switch selectable)
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Trivex, Inc.

MODEL
40/80



CHARACTERISTICS

Keyboard

Display

Format: 12 lines x 80 characters
Size: 9″ x 5″
Character Type: 7 x 9 dot matrix
Character Set: 57-character not including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Move/read by CPU

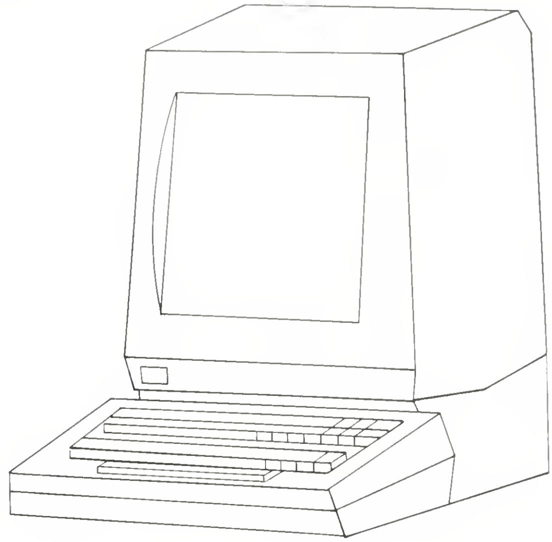
Communications

Interface: RS-232 C, IBM channel
Maximum Transmission Rate: 9600 bps asynchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Univac

MODEL
Uniscope 100



CHARACTERISTICS

Keyboard

Display

Format: 12/16 lines x 64 characters
Size: 5″ x 10″
Character Type: Stroke
Character Set: 64- to 96-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

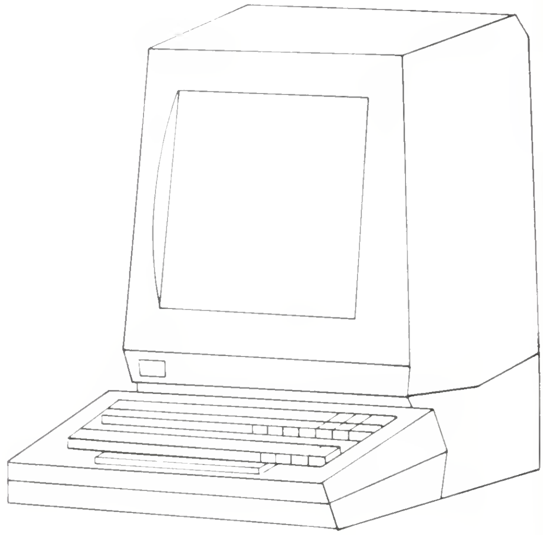
Communications

Interface: RS-232 C, Mil 188
Maximum Transmission Rate: 9600 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Video Data Systems

MODEL
CG-500



CHARACTERISTICS

Keyboard

Display

Format: 8 lines x 32 characters
Size: Any color video
Character Type: 10 x 14 dot matrix
Character Set: 32-character
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

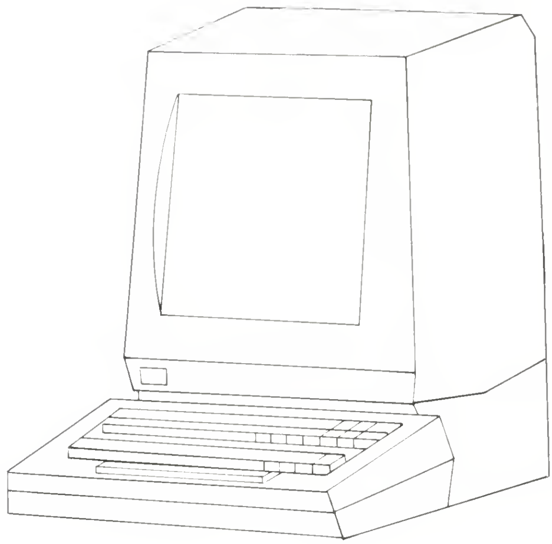
Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 bps asynchronous
Mode: Half duplex
Parity:
Transmission Mode:

Options

MANUFACTURER
Wintek Corp.

MODEL
B-R-B Video Terminal



CHARACTERISTICS

Keyboard

Display

Format: 16 lines x 80 characters
Size: 7″ x 5″
Character Type: Dot matrix
Character Set: 64-character not including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 9600 bps synchronous
Mode: Half and full duplex
Parity:
Transmission Mode:

Options

MANUFACTURER
Wyle Computer Products, Inc.

MODEL
8000 Series

CHARACTERISTICS

Keyboard
66-key ASCII

Display
Format: 12/24 lines x 40/80 characters
Size: 12″ CRT
Character Type: 5 x 7/10 x 14 dot matrix
Character Set: 64-character not including lower case
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: MOS
Cursor: Move/read by CPU & keyboard character underline

Communications
Interface: RS-232 C
Maximum Transmission Rate: 9600 bps asynchronous
Mode: Half or full duplex
Parity: Odd or even
Transmission Mode: Data only

Options
Numeric pad

EVALUATING INTELLIGENT TERMINALS

6

6.1 EVALUATION AND SELECTION

The evaluation and selection of intelligent terminals for interactive computer applications is becoming a difficult and complex task due to the many different configurations and types of terminals in the market, plus a variety of *more intelligent* communication services offered by the common carriers.

In the world of data communications, the efficient integration of equipment and common carrier services often spells the difference between an economical network and one which is costly and inefficient in its optimization of equipment and network services. Frequently, a terminal cannot be selected without reference to the carrier service. For example, the *intelligence* of the network, or lack of it, may determine the minimal configuration which will operate in that network. The network with very little intelligent capability may require an intelligent terminal to meet teleprocessing requirements. Alternatively, the demands of the remote data processing *application* may dictate the terminal category required.

The marketplace is operating on two levels in this area—the common carriers striving to provide more and more capability within the network, and the terminal manufacturers, on their part, trying to incorporate an increasing number of functions in their terminals. As previously discussed in Chapter 4, an intelligent terminal can perform many functions which normally would be performed by the host computer. In a data communications network this can result in considerable savings in communication costs, as well as ensuring that correct information is presented to the host computer.

6.1.1 Characteristics of an Intelligent Terminal

Typically, intelligent terminals have a CRT display associated with the terminal configuration, since most applications require some data screening. The excellent communication characteristics of the CRT in a user/machine interface operation have been incorporated in most intelligent terminal displays. The display allows the operator to monitor and control the input, a mandatory requirement where programming is performed at the keyboard. In addition, the *formatting* and *prompting* characteristics of a display terminal (see Figure 6-1) are considerably better, from an operator viewpoint, than those of a terminal without display (keyboard/printer). Prompting is a widely used technique for cueing programmers and operators on the sequence and format of data input.

To provide the flexibility and versatility required in an intelligent terminal, manufacturers have incorporated a number of additional fea-

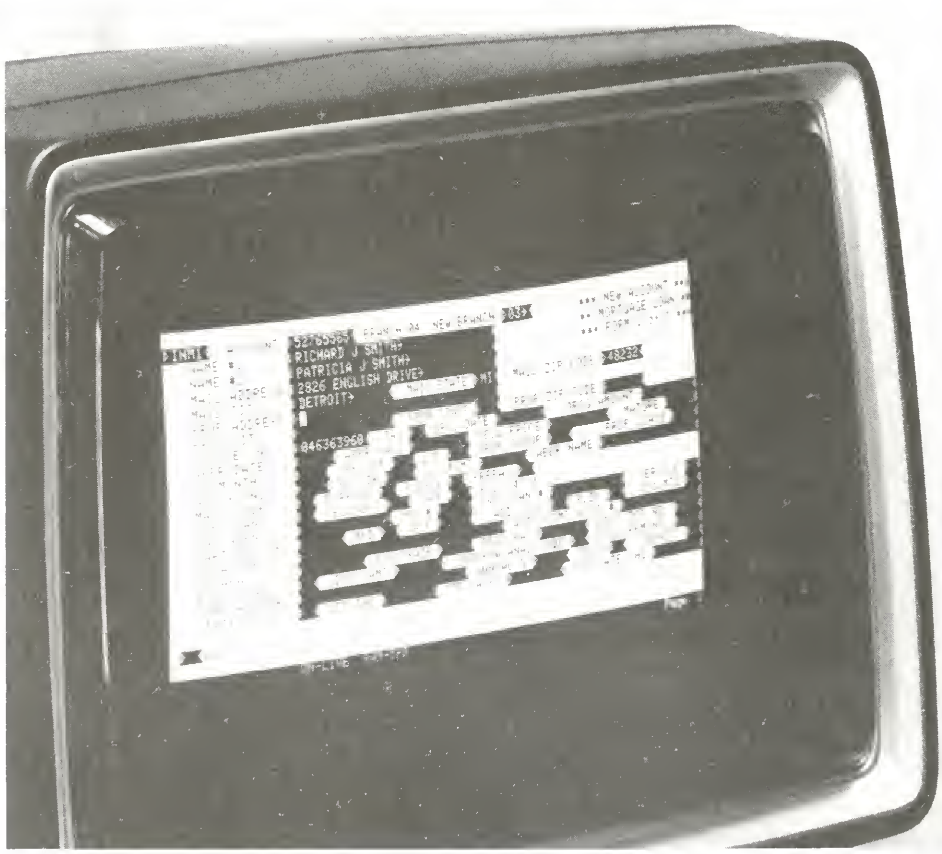


Figure 6–1. An example of a formatted display showing one form of prompting: standard data headings. (Courtesy, Burroughs Corp.)

tures which must be evaluated in any application where an intelligent terminal is required. These characteristics range from special alphanumeric keyboards, numeric pads, and function keys to the type of interim storage available to the user—disk, magnetic tape, or cassette.

The characteristics which should be used to evaluate the display performance of intelligent terminals are essentially the same as for simple terminals with display (see Chapter 5). But in addition, the functional capabilities of the intelligent terminal should be studied. In the following sections, equipment considerations, programming, and applications are discussed. Two typical cases are examined in order to illustrate significant evaluation characteristics.

6.1.2 Equipment Considerations

Intelligent terminals, as defined in this handbook, are *interactive* devices that can be programmed by the user and can communicate with a computer or another terminal. Performance characteristics of interactive terminals which are not user-programmable are described in Chapter 3.

All terminals, whether intelligent or not, should be able to interact with the host computer operating system to perform the following routine operations:

terminal status

time of day

input queue

output queue

output of computer resources used (when signed off)

A CRT controller, whether in an intelligent terminal or not, should be able to move the cursor up, down, left or right, and the raster (*data lines*) up or down. The size and refresh rate of characters on the CRT, which is a human engineering consideration, should enhance operator efficiency. The number of lines and characters per line, essentially a function of the application, offers operator convenience. All of these characteristics have a very obvious effect on the input rate and ease of use of the terminal.

Intelligent terminals are capable of data processing, data preparation, and specialized communications functions, such as emulating other terminals. The percentage of time devoted to each of these functions depends entirelv on the particular application. A typical intelligent terminal consists of the following elements:

keyboard

CRT (or other display)

processor

one or more storage devices

communications emulator, modem and data line

peripheral and communications controller

printer

Since a printer is required for virtually all intelligent terminal applications, it is shown as part of the basic configuration. Typically, it is offered by suppliers as an option to the basic terminal.

Some intelligent terminals are used in clusters of either four or eight devices with a central processor controller. They share peripherals and communications, and generally are used for data preparation and communications where there is a very high volume of data input.

In other applications, the extensive file handling capabilities of an intelligent terminal—which include sorting, merging, and adding or deleting a record—are used. Some simple terminals with manufacturer-programmed functions, allow the *stringing* of a number of files, in a desired sequence, into a single file for transmission to a computer under *operator* control. With intelligent terminals, this is usually done under *program* control.

In the following sections, significant evaluation characteristics of intelligent terminals are described and assessed with respect to their effect on appropriate selection and efficient operation.

Keyboard

Keyboards should have the following features:

an alphanumeric input pad

conformity to a recognized key layout standard, such as QWERTY (see Chapter 3)

a numeric pad

keys to control the CRT

keys to control input, output, and data transfer

keys to provide nonprint special characters to control the printer and to prepare files that can be used within the terminal (or by a computer)

The input pad should have a QWERTY (typewriter) keyboard layout. It is easier to train proficient typists to operate an intelligent terminal than it is to retrain keypunch operators. Moreover, as data entry technology improves, the keypunch layout is becoming obsolete.

A numeric pad significantly increases input where a large share of the data is numeric. Some numeric pads also include a few frequently-used keys to control field input and sign. The numeric pad should be located in a position which will maximize operator convenience.

The CRT control keys should be clustered together for ease of use and should provide maximum control of the raster and the cursor on the CRT (see Chapter 4).

The input/output/transfer keys should be clustered together separately in a convenient location for the operator.

Printer file control characters should be located to the left and right of the input pad for maximum operator convenience. On some keyboards, some of these keys are the upper case of the numeric pad keys. They should all be clearly marked and unambiguous.

Operator Input Capabilities

The number of records entered per day for different operator keystroke-per-hour rates, based on a full five hours of production, is shown in Table 6-1. In an intelligent terminal, the number of strokes required to enter a record is less governed by the record length than it is by the number of fields that are inserted, calculated, and duplicated by the field programs that apply to the record. Much higher data entry rates can be achieved by automating certain routine data entry functions. (See Section 6.2 on page 199 for the significance of the statistics used in Table 6-1.)

Table 6-1. Keystrokes per hour versus number of records per hour for various record lengths and keystroke rates.

	KEYSTROKES/HOUR			
RECORD LENGTH	10,000	12,000	14,000	16,000
20	2,500	3,000	3,500	4,000
40	1,250	1,500	1,750	2,000
60	833	1,000	1,166	1,333
80	625	750	875	1,000

CRT Display

The CRT should be located adjacent to the keyboard for maximum operator convenience. Character size, color of the raster, and refresh rate are human engineering features which should be evaluated for operator convenience, since they obviously will have an effect on productivity.

Raster size for display terminals varies from 7 to 27 lines and 32 to 80 characters per line (see Chapters 3 and 5). In most cases, one or more lines are dedicated for program control information such as error codes, totals, subtotals, program mode, error messages, prompting messages, communications status, and equipment status.

The most common line length is 80 characters. This is based on the fact that most computer records have been input on 80-column cards. This record length is no longer significant in an interactive terminal, because it processes one field at a time and the CRT is not used to list output files for computer input. A full 80-column record requires 80 columns plus one column for an *end of record* (EOR) mark.

A *format* is required on the screen to input records for data processing and/or data preparation. A format consists of a series of input fields. An input field consists of one or more spaces for data and a protected area which includes the field name, several control characters, and, usually, operator prompting information such as field length and type of data. On some terminals, all but the program name, the input data, and the prompting information can be displayed at reduced luminosity or not displayed at all.

Operator efficiency is greatly increased by having a screen or raster size large enough to display the largest format involved in the application.

Processor

Intelligent terminals generally use a *microprocessor*, although a few still use a miniprocessor. The trend toward microprocessors is due to their reduced cost, size, and improved performance. The microprocessor is the heart of the intelligent computer. It is the element which enables the device to be programmed.

Memory

Memory in the processor may consist of one or more of the following three types—ROM (*read-only memory*), PROM (*programmable read-only memory*) and RAM (*random access memory*). Chapter 4 discusses the characteristics of each of these memory types.

ROM. ROM memory varies from 2 KB (2000 bytes or characters) to 8 KB. A ROM memory is *burned in* by the supplier and cannot be

changed by the user. It contains basic operating routines, CRT control routines, and basic control routines for one or two cassettes and a simple printer. A terminal with ROM memory only does not have user-programmable intelligence, and therefore is not classified as an intelligent terminal. Operating capabilities are generally proportional to the size of the ROM memory.

PROM. PROM memory varies from 2 KB to 8 KB. Terminals with PROM only are not classified as intelligent, although the user *can* program a PROM memory as a separate operation. Since PROM is *read only*, it cannot operate as a true programmable memory. It usually contains basic operating and control routines which generally complement those included in a ROM memory (if one is present). If there is no ROM, it contains all basic routines. Terminals with ROM and PROM memory only are not considered *intelligent* and their operating capabilities are generally proportional to the size of the ROM or PROM memory.

RAM. RAM memory is a storage medium which uses a different technology than ROM or PROM. It is completely programmable by the user, and is included in all intelligent terminals described in the specification section of this chapter. It may or may not be used in conjunction with ROM and/or PROM memory. Storage technologies used for RAM include tape cassette, diskette, and magnetic tape (see Figure 6-2). When terminals use RAM memory only, the basic operating system is loaded as part of the user application.

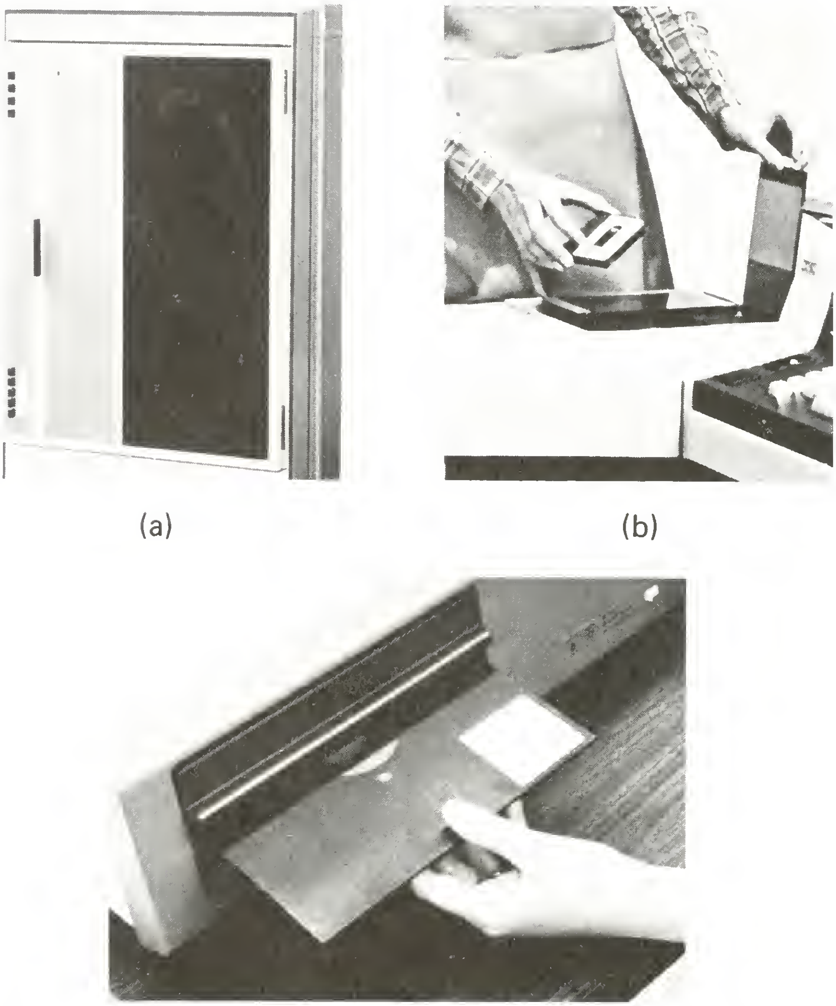
In single keyboard terminals, RAM memory generally varies from 2 KB to 8 KB if ROM and/or PROM memory are included. Where ROM and/or PROM memory are not included, the available RAM memory ranges from 2 KB to 16 KB. Terminals with clusters of four to eight keyboards generally use a common RAM memory of 64 KB.

Most intelligent terminals have page memories where a typical page size is 256 bytes. Input/output buffers are usually one or two pages. The CRT buffer consists of from one to four pages, depending on the raster size of the CRT, since the whole of the CRT buffer (*memory*) is displayed on the screen.

Most processors have a binary index register and up to ten or more alphanumeric registers that can be used as counters or assigned special functions within the user program. All of these registers are accessible from a field program.

Programming

In most intelligent terminals, programming a user application is quite different from programming the same application on a computer. In a



(a) (b)

(c)

Figure 6–2. Different forms of Random Access Memory (RAM).
(a) Magnetic tape. (Courtesy, Hewlett-Packard.) (b) Tape cassette. (Courtesy, AID.) (c) Diskette. (Courtesy, Hewlett-Packard.)

computer, one or more programs are linked together to process data in some predetermined sequence in order to produce output reports. In an intelligent terminal, a series of field programs represents each application, and is controlled by a format displayed on the CRT. A format file is created separately to allow the construction of input records for local data processing and/or data preparation. The following paragraphs describe field program techniques used in intelligent terminals.

A separate format record is required for every different record layout

within an application. Normally, a format consists of a number of fields whose total control and input characters will fit into the CRT buffer and, hence, be displayed in one raster on the screen.

When a format record fits into the CRT buffer and raster, the cursor is automatically reset to the location where the first input data has been written onto a storage device. The operator then can continue inputting records for the format displayed without touching any CRT control keys.

If a format record is longer than the CRT buffer and raster, the format can be split into two or more continuous parts by using special control characters. In this case, the second part is automatically displayed when the last input field of the first part is input, and the cursor will be moved to the first input field in the second part. This continues until the last input field of the last part is processed and the total input data has been written onto a storage device. The format file then is automatically back-spaced to the first part of the format with the cursor positioned in the first input field of the format. The operator can continue inputting records for the multiple part format without touching any CRT control keys.

On some intelligent terminals, when several format records are contained on the format file, whether one or more parts, the operator can press the NEXT FORMAT key to display in sequence the next format on the format file. After the last format on the file, the file is rewound to display the first format on the file. If there are a larger number of formats on the file, the operator can change to *search mode* in order to find the appropriate file. This, however, requires that the first field of each format have a unique identifier. After the correct format is displayed, it is necessary to change back to a data input mode.

Each input file in a format consists of an input area which is the width of the processed field length in the processed data record. A protected area includes the program name, special control characters which indicate whether the field should be skipped, the area in memory where the field program is located, and prompting information for the operator. Protected areas are generally contained within special characters such as square brackets.

After a field is entered, the cursor moves to the first position of the next input field not skipped. When the cursor moves to the first position of an input area, the field program for that program name is called up from memory. The first three or four characters of the program name must be unique so that the correct field program is called up.

An application program is generated as a separate function. This is generally a complex and time-consuming operation. Typically, it consists of three phases in a terminal with cassette memory:

1. The supplier's library tape is loaded on the first cassette with the application program file on the second cassette. The first file on the library tape, which is the *loader,* is copied on the application tape and loaded into memory.
2. All of the routines, peripheral drivers and commands required by the application, are called from the library tape and loaded on the application tape.
3. The user code file for the application is loaded on the first cassette and then processed through memory to the application tape.

Programmable Functions

Some of the functions that can be programmed by intelligent terminals are:

range and contents checking of one or more fields

verification of a check-digit in one or more fields

insertion of a value, calculated by arithmetic procedures, in a field based on the input to one or more fields and/or constants stored in memory

stored duplication, i.e. a value for a file with a certain program name can be entered into memory and then can be inserted in any other field with the same program name, regardless of the format in use

insertion of a constant stored in memory in a field when only a matching code or abbreviation is entered in the field

formatting output forms on the printer when doing local data processing

storing one or more fields on a storage device, from records being prepared for local data processing, for later transmission to a host computer

building records in a dedicated part of core with a field sequence different from that in the format being used. This sequence requires that the record in memory be moved to the I/O buffer before it is written onto an output device

communications emulation—simulating another terminal

Most intelligent terminals are programmed in an assembler-like lan-

guage. Because of memory limitations, programming has to be extremely efficient—*every byte counts.* The commands and drivers called from the supplier's library vary in length from 4 KB to 2 KB. It often is necessary to replace one complex command by two or more simpler commands which require less memory in total.

Printers

Printers are used with intelligent terminals in virtually all applications to list local files or programs, print low- and medium-volume computer output, and print output for local data processing. Character printers are rated in *characters per second* (CPS). Line printers are rated in *lines per minute* (LPM) Tables 6-2 through 6-6 represent a range of user-oriented printer characteristics, which relate printer speed to typical production requirements.

The number of lines per hour for several typical printers (based on the average number of characters per line) is shown in Table 6-2.

The number of pages per hour for several typical printers (based on the average number of characters per line and on 50 lines per page) is shown in Table 6-3.

The number of hours to print a 300-page report for several typical printers (based on the average number of characters per line and on 50 lines per page) is shown in Table 6-4.

Table 6-2. Lines per hour for typical printers and average number of characters per line.

NO. OF CHARACTERS	PRINTER SPEED (CPS OR LPM)				
	80 CPS	165 CPS	100 LPM	300 LPM	600 LPM
40	7,200	14,850	6,000	18,000	36,000
80	3,600	7,425	6,000	18,000	36,000
120	2,400	4,950	6,000	18,000	36,000

Table 6-3. Pages per hour for a range of typical printers.

NO. OF CHARACTERS	PRINTER SPEED (CPS OR LPM)				
	80 CPS	165 CPS	100 LPM	300 LPM	600 LPM
40	144	297	120	360	720
80	72	149	120	360	720
120	48	99	120	360	720

Table 6-4. Time required (hours) by typical printers to print a 300-page report.

NO. OF CHARACTERS	PRINTER SPEED (CPS OR LPM) 80 CPS	165 CPS	100 LPM	300 LPM	600 LPM
40	2.1	1.0	2.5	0.8	0.4
80	4.2	2.0	2.5	0.8	0.4
120	6.3	3.0	2.5	0.8	0.4

See Section 6.2 on page 199 for the significance of the statistics in the preceding tables.

Storage

Programs generally are stored on cassettes or diskettes. Data generally are stored on cassettes, diskettes, or magnetic (mag) tapes. The number of records per volume based on different record lengths is shown in Table 6-5. The number of characters per volume based on different record lengths is shown in Table 6-6.

Table 6-5. Record volumes for various record lengths and storage media.

RECORD LENGTH	STORAGE MEDIUM CASSETTE	DISKETTE	MAG TAPE
80	1668	1898	16,940
256	782	949	13,460

Table 6-6. Character volumes for various record lengths and storage media.

RECORD LENGTH	STORAGE MEDIUM CASSETTE	DISKETTE	MAG TAPE
80	133,400	151,800	1,353,000
256	200,200	242,900	3,445,000

See Section 6.2 for the significance of the statistics in the preceding tables.

Communications

Intelligent terminals generally use medium speed, synchronous, half duplex lines through hardwired modems. Table 6-7 shows the transfer rate for several line speeds (in characters per second) based on 132-character records with no data compression and normal buffers.

The transfer rate (in characters per second) for several peripheral devices, based on 132-character records with no data compression and normal buffers is shown in Table 6-8.

The use of data compression, blocking, and extra buffers can increase the line transfer rates shown in Tables 6-7 and 6-8 by 25 to 75 percent. See Section 6.2 for the significance of the statistics in these tables.

6.2 APPLICATION CONSIDERATIONS

There are a number of criteria to be followed when evaluating intelligent terminals, which are directly related to the particular application and are significant in ensuring that the performance characteristics of the terminal will satisfy its specifications. The following paragraphs describe these criteria in detail.

6.2.1 Memory

The size of memory is one of the most important considerations in any evaluation of intelligent terminals. The basic operating system, whether in ROM or loaded separately in RAM, typically takes 7 KB to 8 KB of memory. *Field programs,* the number of *commands,* and *peripherals* all

Table 6-7. Transfer rates for 132-character records and various baud rates.

BAUD RATE	CPS
1200	113
2000	188
2400	226
4800	451
9600	902

Table 6-8. Transfer rates for various peripheral devices.

DEVICE	CPS
80 CPS Printer	80
165 CPS Printer	165
100 LPM Printer	220
300 LPM Printer	660
600 LPM Printer	1320
Cassette	638
Diskette	25,000
Mag Tape	1803

affect the memory requirements. The number of formats used in a given application does not affect memory since formats are not loaded in memory. The number of different field programs and the number of different commands in all of these field programs, however, has a distinct bearing on the size of the application program and, therefore, the memory requirement.

Peripherals

A *driver* (peripheral control program) has to be loaded from the library for every peripheral used. Magnetic tape drivers usually take about 2 KB of memory, whereas other peripheral drivers typically do not require as much memory.

Emulators

Routines used for communications emulators are so large that an emulator requires a separate applications program. The purpose of an emulator is to enable a terminal to simulate another terminal model so it can be interfaced with a computer or other terminal.

Some computer applications, such as manufacturing, require so many types of record layouts and formats that several application program files may be necessary to cover them all, even with a memory size of 16 KB. These applications require considerable care in allocating different formats to different application files. Only one application program at a time can be loaded in memory. There is some consolation, however, since a program usually can be loaded in a minute or less.

6.2.2 Data Preparation

The main objective of using an intelligent terminal for data preparation (intelligent data entry) is to locate the terminal and operator as close as possible to where the source documents are generated. This avoids the need to prepare secondary input documents, with the obvious inherent chance of error, for a remote data entry center. It also ensures that most source document errors are found while the documents are still in possession of the operator.

6.2.3 Typical Applications

The application of intelligent terminals to remote data communications is a growing field, limited only by the system designer's knowledge and imagination. Some typical applications and guidelines for evaluating intelligent terminals are provided in the following sections.

Case 1

This is a typical case where the terminal is being used for a single application on a host computer, in a small or medium-sized business, for business data processing such as accounts payable, accounts receivable, payroll, or general ledger.

In this case, the number of formats required would be about six with field programs totalling about 60. The typical generated application program would require from 12 KB to 16 KB of memory.

Depending on the type and volume of business involved, the number of records generated would probably be about 2000 per week, with approximately 60 strokes to enter each record. For this case, a record is assumed to be 80 characters long. If the operator were someone from the functional area concerned, the data input operation would take from 10 to 15 hours per week. (See Table 6-1.)

The hardware configuration might include two cassette tapes, 12 KB to 16 KB of memory, an 80 CPS printer, and a 2000-baud line. The total input of 2000 records per week would require the use of two input cassettes per week. (See Section 6-1.)

The operator could list the data input on the local printer at the end of each tape for the entire week and the data entry time required would be about 35 minutes. (See Table 6-4.)

At the end of the week, a transmission file would be prepared using the data files properly merged with the appropriate *job control language* (JCL) files for the application. The transmission time to the host computer would be about 15 minutes. (See Section 6-1.)

The JCL (*day*) file from the host computer for the application run could be printed on the local printer. The output reports probably would be printed on the nearest high-speed printer accessible to the host computer.

In some cases, it is more convenient to transmit input to a computer program designed to accumulate data in a computer file which is called up when the main computer application is run. This applies particularly to computer applications run only monthly, or when a number of cassette tapes are needed. A fairly simple utility program can be installed on the computer which can be called from the terminal to list, sort, and format the accumulated data on the local printer, for validation and audit purposes. In this case, the total monthly input could be listed on the 80-CPS printer in about one hour.

Case 2

This case is similar to Case 1 except that all four applications are input from the terminal.

All of the comments for Case 1, with regard to formats of field pro-

grams and application programs, apply to Case 2. The terminal probably would be a centralized operation with a more highly-skilled operator, so that all records could be input within the week.

As in Case 1, separate application programs are required for each computer application. Careful control must be exercised over data tapes to ensure that the correct tape is mounted for each application. For this case, the printer probably would be upgraded to a higher speed (165 CPS would be a typical speed for a Case 2 application).

6.3 INTELLIGENT TERMINAL SPECIFICATIONS

The following pages in this chapter represent a compilation of the significant performance characteristics of a number of intelligent terminals for which information is available.

The specifications have been organized in a standard format to enable users to make direct comparisons of features offered in each model. This format contains information provided by suppliers and industry information sources and was current at time of publication. Although the selection of terminals is not exhaustive, the author has attempted to include a comprehensive selection of known devices which meet the defined criteria of an intelligent terminal and are being offered to the user market.

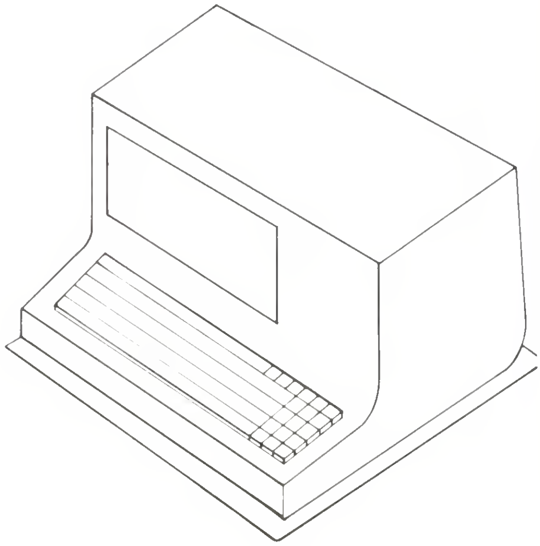
INTELLIGENT TERMINAL

Manufacturer	Model
Applied Digital Data Systems, Inc.	System 70
Beehive Medical Electronics, Inc.	Brilliant Bee Super Bee 2
Bunker Ramo Corp.	System 90
Computek, Inc.	200 series
Datapoint Corp.	Diskette 1100
Delta Data Systems Corp.	Delta 4000 Delta 4550 Delta 5500 Delta 4600/4700 Display and Storage System

Manufacturer	Model
Hewlett-Packard Co.	2640A
Hughes Aircraft Co.	C-9
Imlac Corp.	PDS-1G PDS-4
Incoterm Corp.	SPD 10/20 and 10/25
Lear-Siegler, Inc.	ADM-3
Lektromedia	LEK Series 100 (6 models) LEK 120 (Graphics)
Olivetti	DE 520 DE 525
Omron Corp.	8030
Sanders Data Systems	804
Sycor, Inc.	250 340
Texas Instruments, Inc.	Silent 700
Video Data Systems	CG 1000
Westinghouse Canada, Ltd.	W1600 DE W 1625 W 1630
Zentec	9003

MANUFACTURER
Applied Digital Data Systems, Inc.

MODEL
System 70

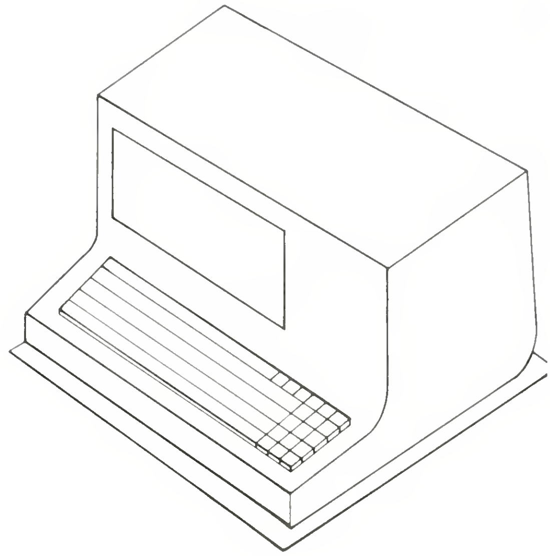


CHARACTERISTICS

Keyboard	Function pad color-coded; numeric pad
Display	
	Format: 24 lines x 80 characters
	Size:
	Character Type:
	Character Set:
	Character Generation:
	Refresh Rate:
	Refresh Memory:
	Cursor:
Functions	Edit data Manipulate files Control printer
Communications	
	Interface:
	Maximum Transmission Rate:
	Mode:
	Parity:
	Transmission Mode:
Options	IBM 3780 protocol

MANUFACTURER
Beehive Medical
Electronics, Inc.

MODEL
Brilliant Bee

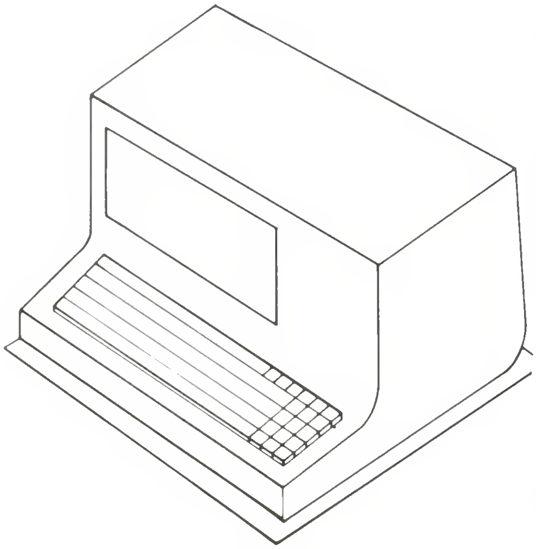


CHARACTERISTICS

Keyboard	80-key detachable
Display	*Format:* 25 lines x 80 characters *Size:* 8.4″ x 6.5″ *Character Type:* 5 x 7 dot matrix *Character Set:* 128-character ASCII (displayable) *Character Generation:* MOS ROM *Refresh Rate:* RAM *Refresh Memory:* *Cursor:* Addressing
Functions	Edit Erase Format Program entry
Communications	*Interface:* RS-232 C *Maximum Transmission Rate:* 9600 baud *Mode:* *Parity:* *Transmission Mode:*

MANUFACTURER
Beehive Medical Electronics, Inc.

MODEL
Super Bee 2

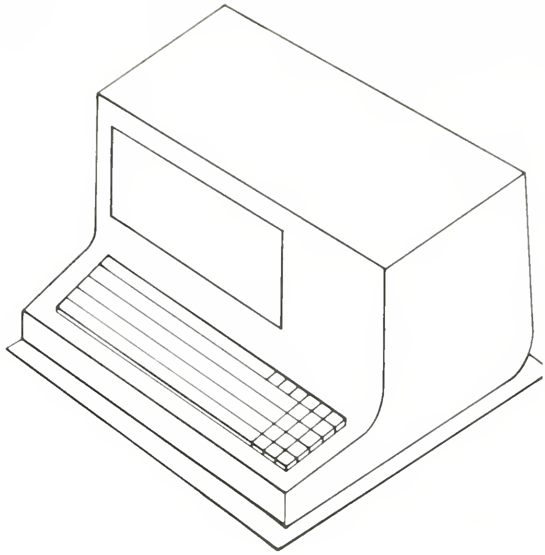


CHARACTERISTICS

Keyboard	106-key detachable
Display	*Format:* 25 lines x 80 characters *Size:* 8.4″ x 6.5″ *Character Type:* 5 x 7 dot matrix *Character Set:* 128-character displayable *Character Generation:* MOS ROM *Refresh Rate:* 60 Hz *Refresh Memory:* MOS shift register *Cursor:*
Functions	Edit Erase Format Program entry
Communications	*Interface:* RS-232 C *Maximum Transmission Rate:* 9600 bps (switch selectable) *Mode:* On-line or off-line *Parity:* Odd, even, none *Transmission Mode:* Character by character transmission

MANUFACTURER
Bunker Ramo Corp.

MODEL
System 90



CHARACTERISTICS

Keyboard

Typewriter style—detachable; 96-key EBCDIC/ASCII; numeric pad; 16-32 function keys; 2-key rollover

Display

Format: 12/24 lines x 80 characters; 6/12 lines x 40 characters
Size: 12″ and 9″
Character Type: 5 x 7 dot matrix
Character Set: 96-character set
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: MOS/RAM
Cursor: Underscore, non-destructive, CPU-controlled, addressable

Functions

IBM 3270 emulator program

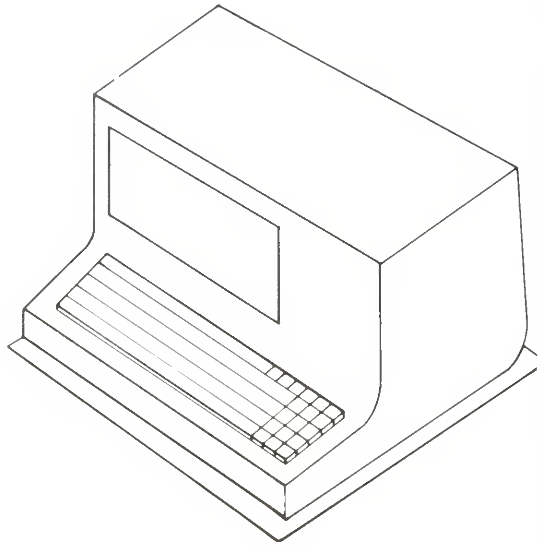
Communications

Interface: RS-232 C
Transmission Rate: 9600 bps
Mode: Half or full duplex
Parity: Odd, even, LRC, CRC
Transmission Mode: Data or full screen

Options

MANUFACTURER
Computek, Inc.

MODEL
200 series



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters
Size: 12″ and 15″ CRT
Character Type: 20 x 14 dot matrix
Character Set: 128-character including lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Moved/read by CPU

Functions

Programmable evaluation

Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 19,200 bps, synchronous
Mode: Half or full duplex
Parity:
Transmission Mode: Data or full screen

MANUFACTURER
Datapoint Corp.

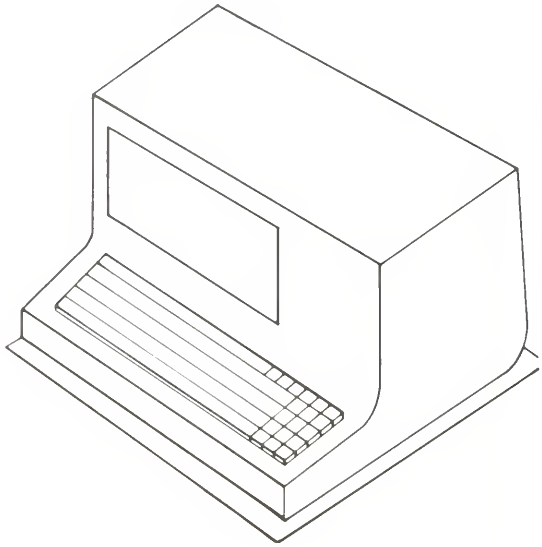
MODEL
Diskette 1100

CHARACTERISTICS

Keyboard	41-key typewriter; 11-key numeric pad; five control keys; audio tones
Display	*Format:* 12 lines x 80 characters *Size:* 7″ x 3.5″ *Character Type:* 5 x 7 dot matrix *Character Set:* 128-character set *Character Generation:* Raster *Refresh Rate:* 60 Hz *Refresh Memory:* RAM *Cursor:* CPU-controlled
Functions	Intelligent data entry, up to 16K memory for user programs
Communications	*Interface:* *Transmission Rate:* *Mode:* *Parity:* *Transmission Mode:* } programmable
Options	Cassette memory 94-character ASCII set

MANUFACTURER
Delta Data Systems Corp.

MODEL
Delta 4000



CHARACTERISTICS

Keyboard

Upper/lower case; numeric; variable between 13 and 80 characters per second; eight program function keys

Display

Format: 25 lines x 80 characters
Size: 14″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 224 displayable characters
Character Generation: MOS ROM
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Nondestructive blinking underscore

Functions

Paging
Editing
Erase

Communications

Interface: RS-232 C, CCITT v.24
Maximum Transmission Rate: 9600 baud (switch-selectable)

	Mode: Half duplex or echo *Parity:* Odd, even, none *Transmission Mode:* Character-by-character, memory or message transmit
Options	Security lock Print mode 50 Hz refresh rate

MANUFACTURER
Delta Data Systems Corp.

MODEL
Delta 4550

CHARACTERISTICS

Keyboard

107 keys; ASCII code; numeric pad, eight programmable function keys

Display

Format: 25 lines x 80 characters
Size: 14″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 224-character, displayable
Character Generation: MOS ROM
Refresh Rate: 60 Hz
Refresh Memory: MOS shift register
Cursor: Blinking underline, cursor controlled

Functions

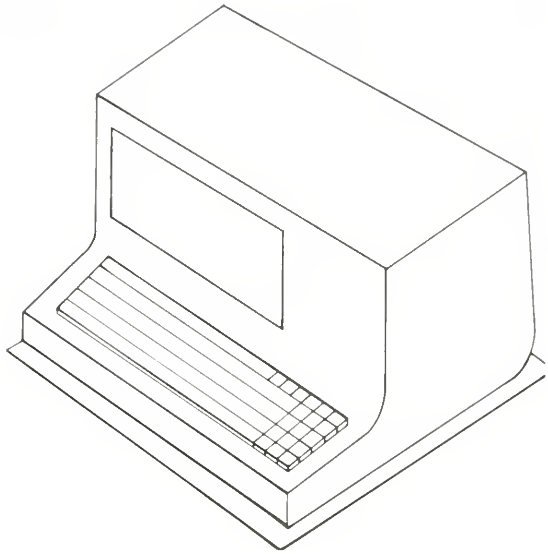
Provides user programmability and protocol emulation

Communications

Interface: RS-232 C or current loop
Maximum Transmission Rate: 9600 baud
Mode: Half duplex or echoplex
Parity: Switchable
Transmission Mode: Block or message

MANUFACTURER
Delta Data Systems Corp.

MODEL
Delta 5500

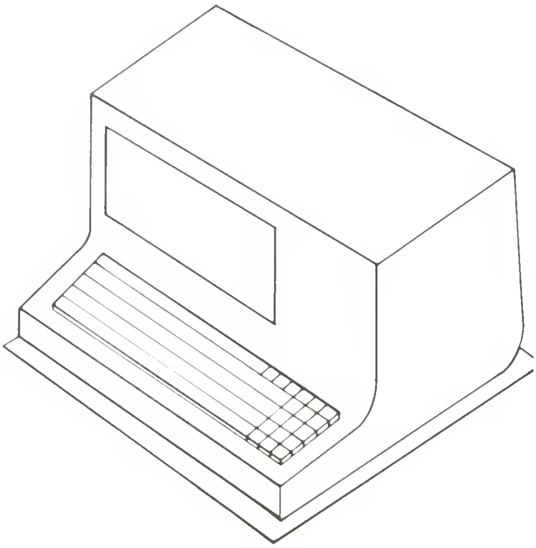


CHARACTERISTICS

Keyboard	40 data keys, 10-key numeric pad, 28 control keys
Display	
	Format: 27 lines x 80 characters *Size:* 14″ CRT *Character Type:* 7 x 9 dot matrix *Character Set:* 64-character *Character Generation:* *Refresh Rate:* 60 Hz *Refresh Memory:* *Cursor:* Blinking underscore
Functions	Edit Erase Format
Communications	
	Interface: Serial, RS-232 C/CCITT v.24 *Maximum Transmission Rate:* 9600 baud asynchronous *Mode:* Half or full duplex *Transmission Mode:* Message or memory
Options	96-character repertoire Upper and lower case

MANUFACTURER
Delta Data Systems Corp.

MODEL
Delta 4600/4700 Display and Storage System



CHARACTERISTICS

Keyboard	107 keys; ASCII code; numeric pad; eight programmable function keys
Display	*Format:* 25 lines x 80 characters *Size:* 14″ CRT *Character Type:* 5 x 7 dot matrix *Character Set:* 224-character, displayable *Character Generation:* MOS ROM *Refresh Rate:* 60 Hz *Refresh Memory:* MOS shift register *Cursor:* Blinking underline, cursor controlled
Functions	Provides off-line storage (to 1.5K characters) through user programmable floppy disc
Communications	*Interface:* RS-232 C or current loop *Maximum Transmission Rate:* 9600 baud *Mode:* Half duplex or echoplex *Parity:* Switchable *Transmission Mode:* Block or message

MANUFACTURER
Hewlett-Packard Co.

MODEL
2640A

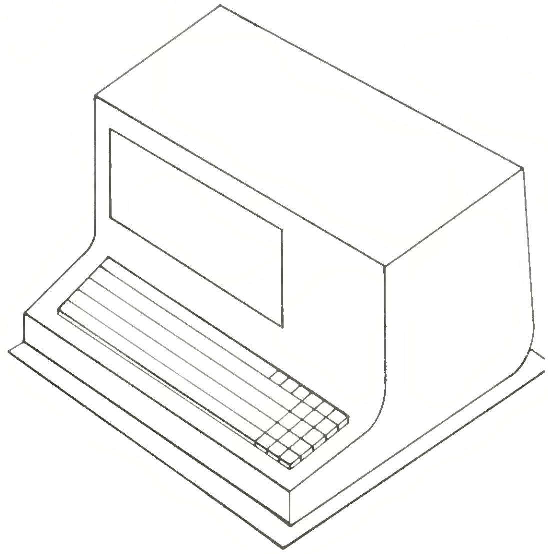
CHARACTERISTICS

Keyboard	Multitask; 10-key numeric pad, tab and page control pad, 22 additional editing, control, and special function keys
Display	*Format:* 24 lines x 80 characters *Size:* 10″ x 5″ *Character Type:* 7 x 9 dot matrix *Character Set:* *Character Generation:* *Refresh Rate:* 60 Hz *Refresh Memory:* *Cursor:*
Functions	Program protected fields in any combination of display positions Scroll up, scroll down, next page, previous page. User-defined routines
Communications	*Interface:* RS-232 C

Maximum Transmission Rate: 2400 baud, asynchronous
Mode: Half or full duplex
Parity:
Transmission Mode: Character, block

MANUFACTURER
Hughes Aircraft Co.

MODEL
C-9



CHARACTERISTICS

Keyboard

TTY-compatible; 128-character ASCII; joystick

Display

Format: 38 lines x 85 characters
Size: 17″ CRT
Character Type:
Character Set: 128-character ASCII
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Cross-hair (graphics); underbar/alphanumerics

Functions

Erase
Curve generator
Italics programmable

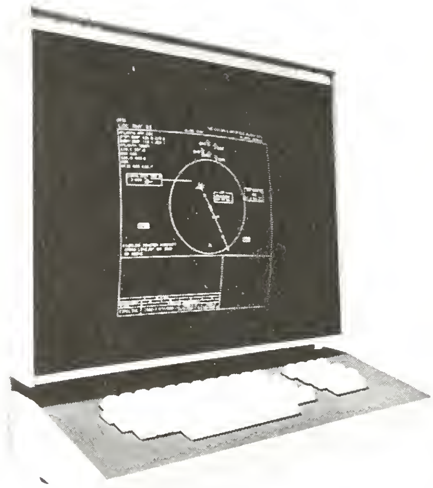
Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 bps, asynchronous
Mode:
Parity: Odd or even
Transmission Mode:

Options

MANUFACTURER
Imlac Corp.

MODEL
PDS-1G



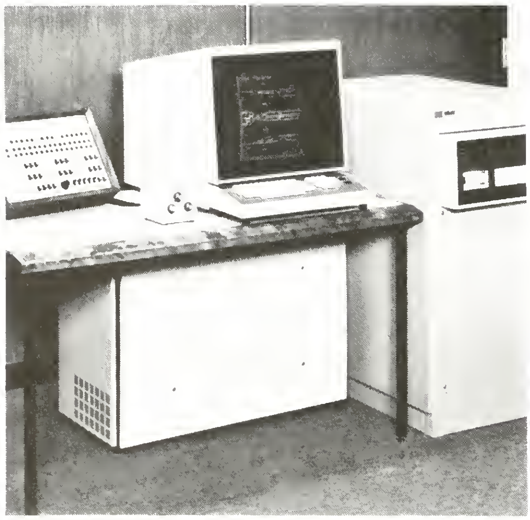
CHARACTERISTICS

Keyboard	Alphanumeric; 67 keys; six user-definable function keys
Display	*Format:* 1450 characters *Size:* 15″ CRT *Character Type:* *Character Set:* 96-character ASCII, upper and lower case *Character Generation:* Read/write memory *Refresh Rate:* 40 Hz; program-controllable *Refresh Memory:* *Cursor:*
Functions	Memory applications Program development
Communications	*Interface:* RS-232 C, current loop *Maximum Transmission Rate:* 600,000 baud

	Mode: *Parity:* *Transmission Mode:*
Options	Light pen Data tablet Joystick Trackball Graphic mouse Other interfaces

MANUFACTURER
Imlac Corp.

MODEL
PDS-4



CHARACTERISTICS

Keyboard
96 ASCII; six function keys, special purpose keys; all keys programmable

Display

Format: 2048 x 2048 display area
Size: 17″ CRT
Character Type:
Character Set: 96-character ASCII plus user-defined symbols
Character Generation:
Refresh Rate: 40 Hz (program-controllable)
Refresh Memory:
Cursor:

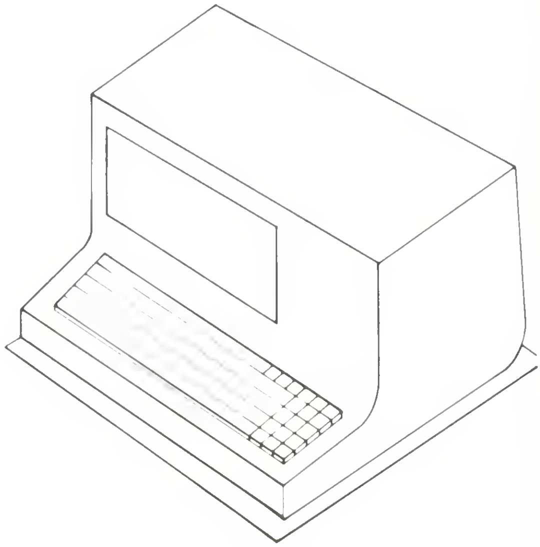
Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 600,000 baud
Mode:
Parity:
Transmission Mode:

Options	Light pen Data table (14″ x 14″) Joystick Trackball Graphic mouse Keyboard Peripherals—disk, magnetic tape, read/write cassette, paper tape, paper tape punch, graphic hard copy

MANUFACTURER
Incoterm Corp.

MODEL
SPD 10/20 and 10/25



CHARACTERISTICS

Keyboard	76-key electronic keyboard
Display	*Format:* 25 lines x 80 characters *Size:* 6.5″ x 9″ *Character Type:* 8 x 12 dot matrix *Character Set:* 128-character including lower case *Character Generation:* *Refresh Rate:* *Refresh Memory:* MOS *Cursor:* Move/read by CPU
Functions	Emulation (Burroughs) Auto answer Polling
Communications	*Interface:* RS-232 C, current loop, parallel (selectable) *Maximum Transmission Rate:* 9600 bps synchronous/asynchronous *Mode:* Half or full duplex

	Parity:
	Transmission Mode: Data or full screen
Options	Remote loading mode

MANUFACTURER
Lear-Siegler, Inc.

MODEL
ADM-3

CHARACTERISTICS

Keyboard — 59 keys, 120 ASCII characters

Display

Format: 12 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 64-character ASCII
Character Generation:
Refresh Rate: 60 Hz
Refresh Memory:
Cursor: Underscore

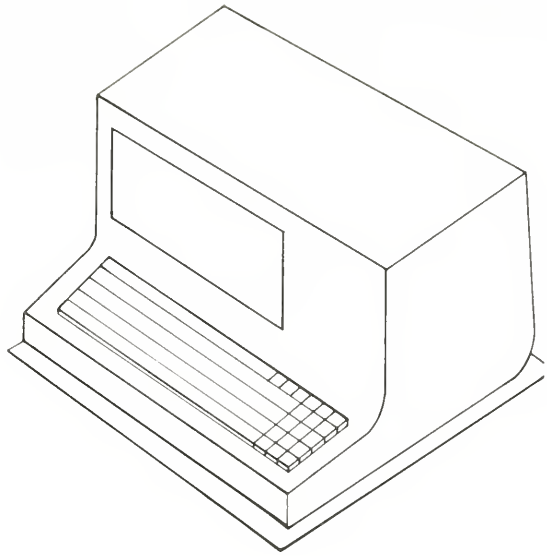
Communications

Interface: RS-232 C, current loop
Maximum Transmission Rate: 19,200 baud (switch selectable)
Mode: Half or full duplex
Parity: Odd or even
Transmission Mode:

Options — 96-character set

MANUFACTURER
Lektromedia

MODEL
LEK Series 100 (6 models)



CHARACTERISTICS

Keyboard

Typewriter style, stepped keys, tactile feedback

Display

Format: 16/24 lines x 80 characters
Size:
Character Type: 5 x 7 dot matrix
Character Set: 96-character ASCII upper and lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Direct addressing

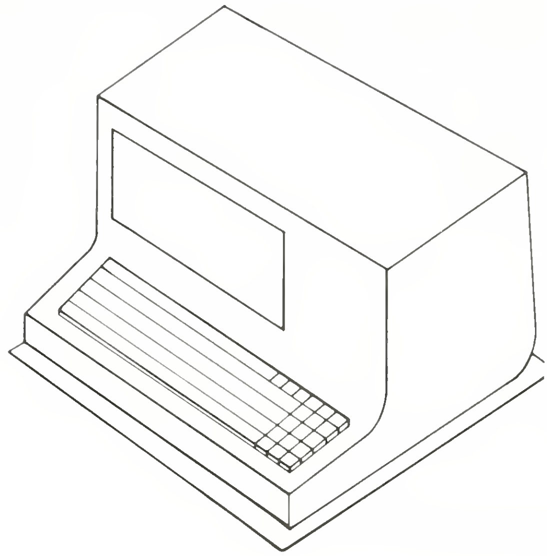
Communications

Interface: RS-232 C
Maximum Transmission Rate: 4800 baud, asynchronous (switch selectable)
Mode: Half or full duplex (switchable)
Parity: Odd, even, mark
Transmission Mode:

Options	9600 baud APL character set Touch sensitive screen Random access audio Current loop User-programmable graphics

MANUFACTURER
Lektromedia

MODEL
LEK 120 (Graphics)



CHARACTERISTICS

Keyboard

Display

Format: 24 lines x 80 characters; 640 x 240 (graphics)
Size: 14″ CRT
Character Type:
Character Set: 96-character ASCII upper and lower case
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

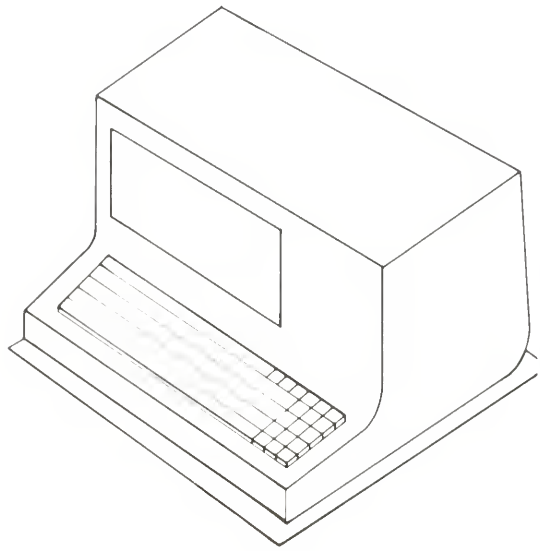
Functions

Communications

Interface: RS-232 C
Maximum Transmission Rate: 1200 baud
Mode:
Parity:
Transmission Mode:

MANUFACTURER
Olivetti

MODEL
DE 520



CHARACTERISTICS

Keyboard

44 alphanumeric; 11-key numeric pad; 11 ASCII code service characters; 29 control keys; three automatic function switches

Display

Format: 11 lines x 30 characters
Size:
Character Type:
Character Set:
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Underscore

Functions

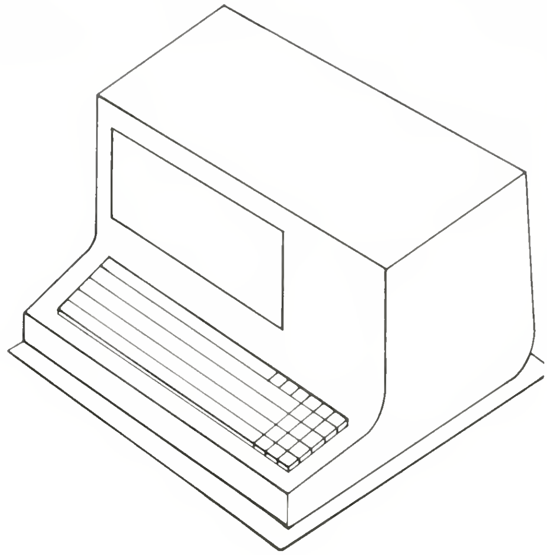
Data entry functions

Communications

Interface:
Maximum Transmission Rate: 2400 baud, synchronous
Mode: Half duplex
Parity:
Transmission Mode:

MANUFACTURER
Olivetti

MODEL
DE 525



CHARACTERISTICS

Keyboard

USASCII standard typewriter, 64 characters; numeric pad; 28 function keys

Display

Format: 11 lines x 31 characters
Size:
Character Type:
Character Set:
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Functions

Numerous data entry user-programmed functions

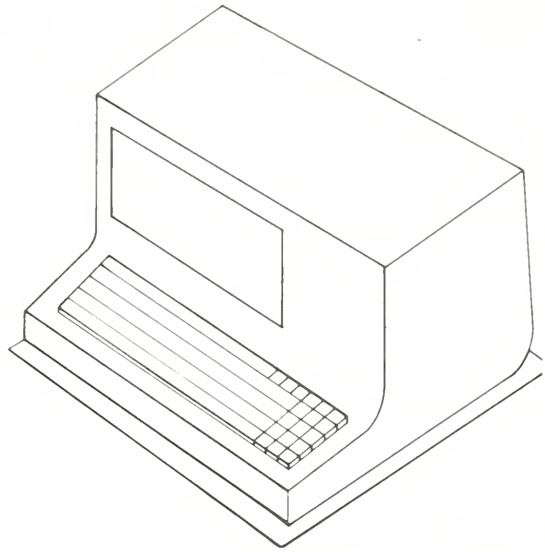
Communications

Interface:
Maximum Transmission Rate: 4800 baud
Mode:

	Parity:
	Transmission Mode:
Options	96-character upper and lower case keyboard Peripherals

MANUFACTURER
Omron Corp.

MODEL
8030



CHARACTERISTICS

Keyboard — 95 keys

Display

Format: 24 lines x 80 characters
Size: 15″ CRT
Character Type: 9 x 14 dot matrix
Character Set: 128-character set
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: RAM
Cursor: Blinking and block
CPU controlled

Functions — Edit functions
Communications control

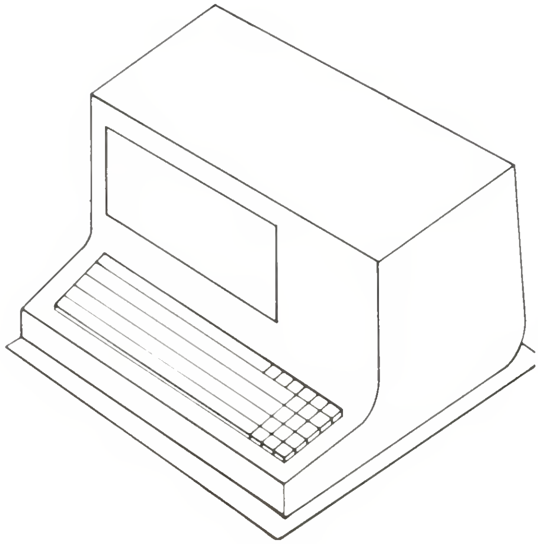
Communications

Interface: RS-232 C
Transmission Rate: 9600 baud
Mode: Half or full duplex
Parity: Odd, even, none
Transmission Mode: Data and full screen

Options

MANUFACTURER
Sanders Data Systems

MODEL
804



CHARACTERISTICS

Keyboard — ASCII typewriter-style; numeric pad; function keys

Display

Format: 12 lines x 80 characters or 15 lines x 64 characters
Size: 12″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 96-character
Character Generation:
Refresh Rate: 50 or 60 Hz
Refresh Memory:
Cursor:

Functions — Programmable terminal controller

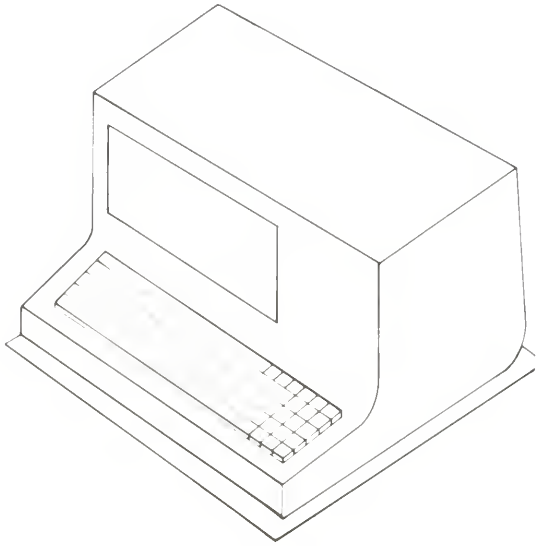
Communications

Interface: RS-232 C or TTL
Maximum Transmission Rate: 1800 bps asynchronous; 9600 bps synchronous
Mode: Half or full duplex
Parity:
Transmission Mode:

Options	24 lines x 80 characters Internal modem Upper and lower case Four keyboard styles

MANUFACTURER
Sycor

MODEL
250



CHARACTERISTICS

Keyboard: Typewriter

Display

Format:
Size: 12″ CRT
Character Type: 7 x 9 dot matrix
Character Set: 64-character ASCII
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Functions

Communications

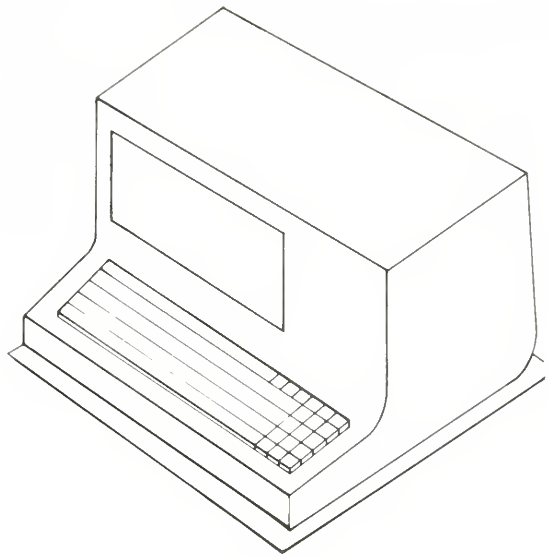
Interface: RS-232 C
Maximum Transmission Rate: 7200 bps synchronous
Mode: Half duplex
Parity:
Transmission Mode:

Options

Data entry keyboard
Numeric pad
Peripherals
Light pen

MANUFACTURER
Sycor, Inc.

MODEL
340



CHARACTERISTICS

Keyboard

26 alphabetic keys, 10 numeric—both typewriter and adding machine; 32 special symbols; 23 function keys

Display

Format: 9 lines x 64 characters
Size: 9″ CRT
Character Type: 5 x 7 dot matrix
Character Set: 62-character ASCII
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

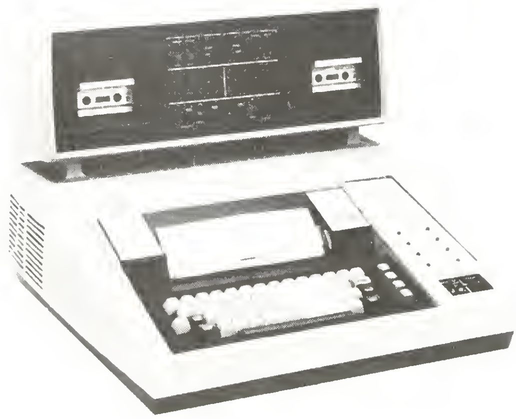
Functions

Communications

Interface: RS-232 C
Maximum Transmission Rate: 4800 bps synchronous; 1200 bps asynchronous
Mode:
Parity: Odd or even
Transmission Mode:

MANUFACTURER
Texas Instruments, Inc.

MODEL
Silent 700
(No display)



CHARACTERISTICS

Keyboard — 97-character USASCII; 2-key rollover; 12-key numeric pad

Printer

Format: 80 characters/line
Size: 8-inch line length
Character Type: 5 x 7 dot matrix
Character Set:
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor:

Functions

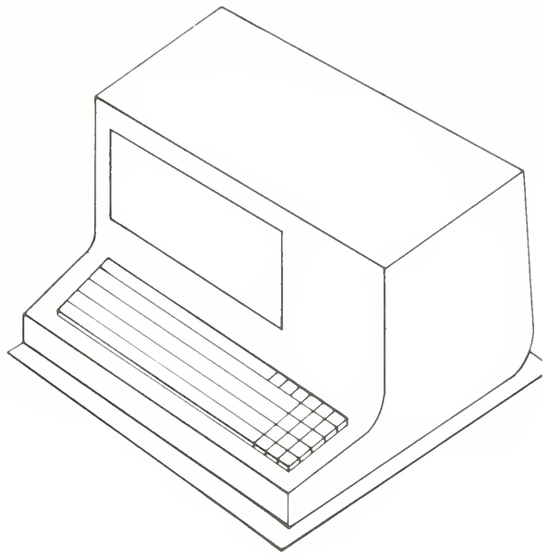
Communications

Interface: RS-232 C
Maximum Transmission Rate:
Mode:
Parity:
Transmission Mode:

Options — Built-in 1200 baud modem

MANUFACTURER
Video Data Systems

MODEL
CG1000



CHARACTERISTICS

Keyboard

67 keys

Display

Format: 8 lines x 32 characters
Size: Depends on monitor
Character Type: 10 x 14 dot matrix
Character Set: 64-character set
Character Generation: MOS
Refresh Rate: 60 Hz
Refresh Memory: RAM
Cursor: None

Functions

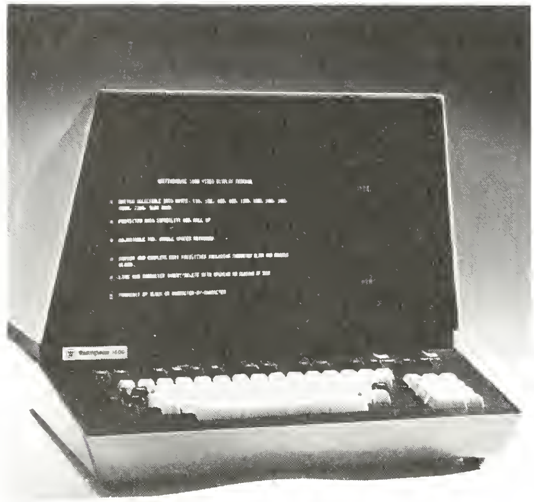
Communications

Interface: RS-232 C
Transmission Rate: 9600 baud
Mode: Half duplex
Parity:
Transmission Mode: Data or full screen

Options

MANUFACTURER
Westinghouse Canada, Ltd.

MODEL
W1600 DE



CHARACTERISTICS

Keyboard	38 data keys
Display	*Format:* 20 lines x 80 characters *Size:* 14″ x 18″ *Character Type:* 5 x 7 dot matrix *Character Set:* 64-character USASCII *Character Generation:* *Refresh Rate:* 60 Hz *Refresh Memory:* MOS semiconductor *Cursor:*
Communications	*Interface:* Modified EIA RS-232 C *Maximum Transmission Rate:* *Mode:* Half or full duplex *Parity:* *Transmission Mode:*
Options	

MANUFACTURER
Westinghouse Canada, Ltd.

MODEL
W 1625

CHARACTERISTICS

Keyboard

96 keys; preselection of 96- or 128-code set; switch type—sealed magnetic reed

Display

Format: 24 lines x 80 characters
Size: 12″ CRT
Character Type: 5 x 7 and 8 x 10 (graphics) dot matrix
Character Set: 64-character ASCII upper and lower case; 96-character (7-bit) ASCII; 128 characters
Character Generation:
Refresh Rate:
Refresh Memory:
Cursor: Nondestructive block

Functions

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 baud asynchronous (switch selectable)

Mode: Half or full duplex
Parity: Odd, even, mark (switch selectable)
Transmission Mode: Character-by-character, block

MANUFACTURER
Westinghouse Canada, Ltd.

MODEL
W 1630

CHARACTERISTICS

Keyboard — 63 keys, ASCII

Display

Format: 23/24 lines x 80/64 characters
Size: 9.4″ x 6.7″
Character Type: 5 x 7 and 5 x 9 dot matrix
Character Set: 128-alphanumerics; control and graphic symbols
Character Generation:
Refresh Rate: 60/50 Hz
Refresh Memory:
Cursor: Reversed 'L'; nondestructive

Functions — Formatting: line and character insert and delete

Communications

Interface: RS-232 C
Maximum Transmission Rate: 9600 bps synchronous
Mode: Full duplex
Parity: Odd or even
Transmission Mode: Block

MANUFACTURER
Zentec Corp.

MODEL
9003

CHARACTERISTICS

Keyboard	97 keys, numeric pad, ASCII and function keys
Display	*Format:* 25 lines x 80 characters *Size:* 15″ CRT *Character Type:* 7 x 9 dot matrix *Character Set:* *Character Generation:* ROM *Refresh Rate:* 60 Hz *Refresh Memory:* RAM *Cursor:* Underscore, blinking cursor controlled by CPU.
Communications	*Interface:* RS-232 C *Transmission Rate:* 9600 baud *Mode:* Half or full duplex *Parity:* Odd, even, switch selectable *Transmission Mode:* Data and full screen
Options	50 Hz refresh rate

PROTOCOLS AND STANDARDS

7

Standard formats and procedures, referred to as *protocols* in data communications, are a desirable feature of any communication system. They enable different types of equipment to interface with a network. Two main interfaces in an interactive terminal are *operator* and *communications*. A variety of world-wide standards are available in terminal devices with varying degrees of compatibility with each other. However, some standard and protocol formats are incompatible, and users should be aware of these incompatibilities.

7.1 OPERATOR INTERFACE

The physical features of data terminal equipment used by a terminal operator are referred to as the *operator* interface. Procedures for protocols used by an operator when sending and receiving data from a host computer system or another terminal also are a part of the operator interface. There are two major areas where operator interface may be standardized—physical design and protocol.

7.1.1 Physical Design

There is a wide variety of input and output devices capable of being attached to data terminals. Options offered by manufacturers for input and output devices add to the many possible equipment configurations. As noted in earlier chapters of this handbook, the alphanumeric keyboard is the most common terminal input device. The basic keyboard arrange-

ment is usually a QWERTY standard, surrounded by a variety of optional and function keys.

In output devices, hard copy printers and CRT displays are most common. Standards and protocols are included in this chapter, where available, for the following peripheral devices:

1. *Input*
   Alphanumeric keyboards
   Function keyboards
   Light pencils
2. *Output*
   Printers
   CRT displays
3. *Combined Input/Output*
   Magnetic tape cassettes
   Magnetic disks
   Magnetic tape

Published peripheral standards are generally applicable to devices such as keyboards, card readers and punches, paper tape devices, and standard (½ inch) magnetic tape units. Magnetic tape cassettes, disks, diskettes, CRTs and keyboards have not been standardized to a common specification, and a number of different standards are available.

The following sections review the current standards used for each device, and the standardizing committees and agencies responsible for published standards and for ongoing standardization projects. Table 7-1 contains a summary list of these organizations.

Table 7-1. Standardization organizations.

ORGANIZATION AND ABBREVIATION	AREAS OF INTEREST
Canadian Standards Association (CSA)	All of the organizations listed have published standards in one or more areas of terminal design, data code, interface, and peripheral specifications
American Society for Communications (ASC)	
Information Interchange (ASCII)	
International Standards Organization (ISO)	
American National Standards Institute (ANSI)	
International Consultative Committee for Telephone and Telegraph (CCITT)	
Electronic Industries Association (EIA)	

Input Devices

Alphanumeric keyboards. The most widely accepted North American standards for 44-key typewriter keyboards are the ISO R1091 and ANSI X47. ANSI standard X4.14 contains two typewriter keyboard arrangements, which include ASCII characters (ANSI standard X3.4). Both keyboard arrangements and the previously mentioned standards have a common QWERTY layout as shown in Figure 7-1. No standards have been published for keyswitch physical characteristics—size, shape, slope, skew, spacing, etc.

Various "standard" keyboards have from 44 to 48 keys. The optional keys are shown dotted in Figure 7-1. These standards assign the ASCII and other special printable graphics to the upper cases of the 1 through 0, comma, decimal, and blank keys shown in Figure 7-1. The remaining keys are used to print upper and lower case alphabetic characters. The assignment of special graphics differs among the three standards—ISO R1091, ANSI X4.7 and ANSI X4.14. The ANSI X4.14 standard specifies which keys shall be used to produce nonprinting ASCII control characters such as SOH and ETX. A standard to define the graphics for these characters is under development by ANSI.

Where a Baudot keyboard is used for 5-level Baudot transmission, it generally has a modified QWERTY base with the top row of keys missing and numerals produced by the upper case keys in the QWERTY row.

Although all manufacturers use the QWERTY base in their typewriter keyboards, the assignment of special characters and control characters may vary considerably. Some standard or *full* ASCII keyboards differ from both ANSI keyboard standards, but do provide the basic or full set of ASCII characters.

Two standards, the ISO R1091 and the ANSI X4.6 define spacing and organization of keys on 10-key numeric keypads. There is no reference to standardized key shapes or dimensions. Numeric keyboards offered

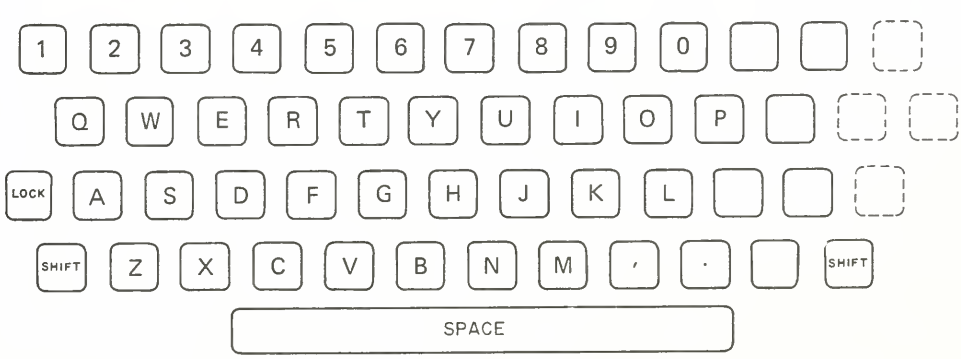


Figure 7–1. Standard QWERTY keyboard layout.

by most suppliers meet the 10-key numeric pad standard. Typewriter keyboards with an adding machine insert, however, usually do not conform to either adding machine or typewriter keyboard standards.

Function Keys

There are no published standards which apply to function keys. Some of the keyboard standards just discussed cover the location of control keys for those functions defined within the ASCII character set (see Figure 7-2 and Chapter 3). Many data terminals contain a number of other nec-

CHARACTER	8-BIT OCTAL	6-BIT OCTAL	CHARACTER	8-BIT OCTAL	6-BIT OCTAL
A	301	01	!	241	41
B	302	02	"	242	42
C	303	03	#	243	43
D	304	04	$	244	44
E	305	05	%	245	45
F	306	06	&	246	46
G	307	07	'	247	47
H	310	10	(	250	50
I	311	11	)	251	51
J	312	12	*	252	52
K	313	13	+	253	53
L	314	14	,	254	54
M	315	15	-	255	55
N	316	16	.	256	56
O	317	17	/	257	57
P	320	20	:	272	72
Q	321	21	;	273	73
R	322	22	<	274	74
S	323	23	=	275	75
T	324	24	>	276	76
U	325	25	?	277	77
V	326	26	@	300	
W	327	27	[	333	33
X	330	30	\	334	34
Y	331	31	]	335	35
Z	332	32	↑	336	36
0	260	60	←	337	37
1	261	61	Leader/Trailer	200	
2	262	62	LINE FEED	212	
3	263	63	Carriage RETURN	215	
4	264	64	SPACE	240	40
5	265	65	RUBOUT	377	
6	266	66	BLANK	000	
7	267	67	BELL	207	
8	270	70	TAB	211	
9	271	71	FORM	214	

Figure 7–2. ASCII character set.

essary function keys. The most prevalent is the cursor-positioning control on a CRT display. Other function keys generally included on an interactive terminal keyboard include those which initiate processor activity for a series of operations at the terminal or the host computer. This activity may consist of single operations such as character or line insertion and deletion under terminal control, or complex calculations executed at the host computer on previously entered data.

The typical function keyboard is located on the right side of the keyboard console separate from the keyboard section which is used for data entry. There are interactive terminals, however, which have function keys across the top of the keyboard.

A trend toward standardization of the functions performed by a CRT function keyboard is apparent from manufacturers' specifications. These functions include up-space, down-space, new-line, new-screen, erase-line, and erase-page, as well as normal keyboard forward and back space functions.

Functions that are initiated by a function keyboard cover a wide variety of operations, and no generally-accepted standards have been established. Functions such as cursor control may be the subject of future standardization for key functions and positions.

Light Pencil

This is an optional input device offered by some terminal manufacturers. No common standards have been developed to control the design of light pencils. When used with CRT displays they are actually sensing devices. Screen position is determined by the response of the pencil to the light emitted as the electron beam scans the CRT screen. This position is interpreted by electronic circuitry, and appropriate action is taken on the required data, as "illuminated" by the light pencil.

Printers

No published standards are available for the physical features of printers used with interactive terminals, either as an integral part of the terminal or as an optional device. Horizontal spacings of ten and twelve characters per inch (optional) are used throughout the industry. For vertical spacing, six characters per inch is a generally-accepted criterion, with options of three and eight characters per inch.

The range of pin and friction feed platen sizes in interactive terminals allows 72, 80, 120, or 132 print positions to be used. In pin feed platen design, $\frac{1}{2}$-inch pin spacing and pin size of $\frac{5}{32}$-inch, have become accepted as common practice in the industry.

Printing fonts in interactive terminals are not standardized, and printer manufacturers offer a choice of fonts.

A variety of printing techniques (type-ball, print wheel, print chain, etc.) are available to users. No international standards have been published. Certain techniques have become popular with users, however, and terminal manufacturers themselves tend to standardize the techniques which are accepted by users. Chapter 2 describes printer technology in detail.

CRT Displays

Existing standards for CRT displays relate to radiation hazards and electrical characteristics. There are no published standards relating to the number of characters per line, the number of lines on the screen, or other display characteristics. However, CRTs in interactive terminals with displays, have some elements which are found in the majority of devices, such as 5 x 7 dot matrices for character generation, 80 characters per line and 24 lines per screen, and screen intensity controls. Options available in CRT displays used in interactive terminals include:

- color
- video
- various blinking rates
- levels of intensity
- cursor types (destructive and nondestructive)
- split-screen capability

Random Access Memory

Chapters 4 and 6 describe random access memory (RAM) in detail. RAM for interactive terminals may be:

- magnetic tape cassette
- removable magnetic disk (diskette, "floppy," or flexible disk)
- one-half inch magnetic tape

Magnetic Tape Cassette

Tape cassettes are devices used on some interactive terminals with random access memory to store data locally. No published standards are

available for physical dimensions or recording techniques. However, the physical dimensions of the Philips tape cassette has been adopted by many manufacturers. Tape cassettes use a variety of speeds and recording densities, and while they may be physically interchangeable, one machine may not necessarily be capable of reading data recorded on another.

Interchangeable Magnetic Disks

Interchangeable disks (diskettes, "floppy disks") as a storage medium for interactive terminals are being used by some manufacturers, although no published standards are available.

One-Half Inch Magnetic Tape

The use of one-half inch magnetic tape is widespread throughout the data processing industry, and a number of standards are available defining coding structure and physical dimensions. Few interactive terminal manufacturers, however, use this medium as a storage device.

7.1.2 Operator Protocol

All data terminals require operator protocols to communicate with computers and other terminals. Among the significant operator protocols are the following:

- sign-on to the computer system
- termination
- operator identification
- terminal identification and location
- data entry

Operator protocols almost always are determined by host computer terminal support software, which is designed to operate interactively with computer operating systems. An example of the control exercised by most computer operating systems is illustrated by sign-on procedures where the operator is asked to enter his location, name, password, and perhaps other information required to permit the operator to access application programs stored in the host computer.

Apart from published standards related to the entry of date information, geographical location, and operator identification there are few standardized operator protocols. The area of operator protocol is one in

which complete standardization will be difficult. As one reference document[1] points out, " . . . there are as many sign-on procedures as there are software systems." Operator protocols are a dynamic area in interactive terminal technology, and it is difficult to foresee how standardization can be accomplished to any significant degree.

7.2 COMMUNICATIONS INTERFACE

The communications interface refers to:

- the electrical and mechanical connection between a terminal and common carrier network
- the communications procedures established between terminal and host computer, part of which are data codes for transmitting and receiving data

Standards for the communications interface are discussed under physical design and communications line interface and line discipline, including data codes and line protocol procedures for interfacing terminals with the communications facility.

7.2.1 Physical Design and Line Interface

EIA RS-232 C is the most widely used standard for electrical interface between interactive terminals and common carrier facilities. It is an electrical interconnection standard defining the interface between the terminal and carrier facilities.

The U.S. military standard is Mil 188 and is similar to RS-232 C, as is CCITT v.24. Common carriers specify either the EIA RS-232 C or the CCITT v.24 standard for terminals which are to be attached to their facilities.

Data transmission on wide band data circuits is controlled by an AT&T standard, a variation of the EIA RS-232 B standard, and is equivalent to the CCITT v.35 standard for transmission over wide band circuits.

Transmission of asynchronous data at 75 and 110 baud is the subject of two standards developed through common usage. The 20 mA current loop is used for TTY-compatible terminals transmitting at 110 baud. Teletype Models 33 and 35, for example, use this standard.

Built-in modems and nonstandard interfaces which are used in some terminals usually operate on conditioned leased lines, where conditioning

[1]CRC Report No. 1275 "Data Terminal Standards and Protocols." Department of Communications, Ottawa, Ontario, 1975, p. 51.

is used to improve circuit characteristics. Terminal users are responsible for ensuring compatibility between terminal and host computer modems. For synchronous data transmission, the EIA RS-334 standard (referenced in RS-232) is *signal quality at interface between data processing terminal equipment and synchronous data communication equipment for serial data transmission*. It specifies the distortion tolerance. The equivalent ANSI standard is X3.24.

Transmission Speeds

Data transmission speeds are influenced by electrical characteristics, especially data channel bandwidth. In the United States, a 4 kHz voice channel is normally used with transmission of synchronous signals at 2400, 4800 or 9600 bits per second. In Canada, two grades of analog transmission facilities are offered—sub-voice grade for transmission of asynchronous data up to 300 baud, and voice-grade circuits for higher data rates. For transmissions above 9600 bps, several parallel voice channels are used on a Telpak circuit. Canadian carriers offer transmission speeds from 75 to 50,000 bits per second.

EIA RS-269 A specifies signalling rates for synchronous transmission, and this standard is widely accepted by carriers in the United States. This standard specifies that the serial signalling rate shall be a multiple of 600 bits per second. Preferred signalling rates under this standard are 600, 1200, 2400, 4800, 7200 and 9600 bits per second. However, 2000 bits per second is recognized as an interim standard. Below 600 bits per second, the standard rates of 75, 150, and 300 bits per second apply.

7.2.2 Line Discipline

Line protocols for interactive terminals have been standardized in two main categories:

data code structures for the terminal itself

line discipline or protocol used for logical synchronization between terminal and the host computer or other terminal

Published standards for both of these categories have been prepared by standardization agencies shown in Table 7-1.

Data Codes

Data code standards include:

ISO Standard R646 (establishes the international version of ASCII)

CSA Standard z243.4

The Canadian standard (CSA Standard z243.19) actually consists of two sets of character codes—ANSI Standard X3.4 (ASCII) and ISO R646 Standard.

All of the referenced data code standards permit a manufacturer to use certain codes for user-specified device control functions. This makes it difficult to determine the degree of adherence to the ASCII code, where a terminal specification calls up the ASCII code.

A number of other data codes are used by manufacturers and may be required to meet individual terminal user needs. Four of the most common codes, other than ASCII, are:

Baudot code (5-level)

EBCDIC

BCD code

Transcode

The Baudot code is widely used because there are many installed terminals designed for it. However, ASCII and EBCDIC are the most common data codes used in more recently designed equipment.

All data codes reserve certain characters or sequences of characters for control functions. These usually are interpreted at the terminal by hardware or software rather than by the operator. Some terminals use unassigned bit patterns for unique functions, such as activating peripheral devices or controlling CRT displays.

Software facilities in most host computers enable them to handle several different data codes. Both the terminal and the host computer communications control units, however, are generally code-sensitive—designed for specific data code structures. All data codes transmitted on common carrier facilities are *serial-by-bit*. ASCII code structure specifies transmission by bits from the *low order* (the rightmost bit is transmitted first) as specified in CSA z243.11, ISO R1177, and ANSI X3.16. On the other hand, EBCDIC data code specifies transmission of the *high order* (leftmost bit) first.

Many interactive terminals are *start/stop* or asynchronous devices where timing of the transmitted signal is re-established with each character. Published standards allow for transmission of ASCII codes in a start/stop transmission mode, with one start bit, zero or one parity bit, and one or two stop bits. A parity bit may establish even or odd parity, or may be always set to one. CSA z243.11, ISO R1177, ANSI X3.15, and X3.16 specify the criteria for determining the number of stop bits and the

sense of the parity bit. In practice, these standards are not strictly interpreted. For this reason, all of the referenced standards permit some variety of combinations among terminal manufacturers and users. Other codes use different start and stop bits as follows:

> the 5-level Baudot code—one start bit, 1, 1.42 or 1.5 stop bits, without parity
>
> EBCDIC, BCD and Correspondence codes—one start, one stop, and a parity bit

EBCDIC, ASCII, and 6-level Transcode are used for synchronous transmission, which establishes synchronization for transmission of a block of characters. This transmission technique requires no stop or start bits on each character, since all data in a block is transmitted continuously. For synchronous transmission, an interactive terminal requires a buffer large enough to contain at least one block of data. Most coding structures accommodate a block check character. The standard for CSA z243.19 requires a *longitudinal redundancy check* (LRC) character. The LRC is a parity balancing character at the end of a string of characters comprising a message, normally terminating with an END control character. IBM has established one standard called the *cyclic redundancy check* (CRC) method which calculates a check character of 12 or 16 bits using an algebraic algorithm.

Line Protocols

Line protocols frequently are associated with a particular code structure. This association, however, is not necessary from a standardization viewpoint. CSA Standard z243.13 is equivalent to ISO Standard R1745 (Basic Mode Control Procedures), which differs in detail from the ANSI X3.28 Standard.

There are a number of other accepted techniques, most of them derived from the Bell System and IBM. The most common published standards and those developed through usage are the IBM Binary Synchronous Communications (BSC) conventions and the teletypewriter protocols used by the Bell System. The BSC convention is a dynamic standard continually under development. It can use EBCDIC, ASCII, or the Transcode code structures.

Users tend to design customized line protocols for their own applications because operating improvements and cost savings can be achieved by developing protocols to suit a particular application. Most line protocols are designed for efficient data flow in one direction, with acknowledgement messages in the opposite direction. This means that a line must

be logically *turned around* for each data flow reversal. Where heavy data traffic in both directions is involved, time lost in turnarounds can reduce the efficiency of a data communications system.

Line Protocol Standards Under Development[2]

Modifying line protocol to facilitate simultaneous data traffic in both directions can improve data performance characteristics, enabling a lower capacity line to accommodate greater traffic volumes. CSA, ISO and ANSI are developing *high-level data link control* (HDLC) standards. IBM is developing a *synchronous data link control* (SDLC) procedure, under a new communications systems architecture called Systems Network Architecture (SNA).[3] SNA establishes conventions for:

line control discipline (SDLC)

communications access method (VTAM)

communications control program (NCP/VS)

Each of these areas is integral to SNA. One of the major benefits of SNA is to provide users of telecommunications systems with a method of using data processing capability without having to be concerned with the idiosyncracies of different communications procedures.

SNA and BSC are not directly comparable. SNA is a communication system architecture and broader in scope than BSC, a line control discipline. A more appropriate comparison would be between SNA and the entire BSC teleprocessing environment.

Unlike the BSC environment, where separate terminals and different communications lines are often required for each type of application, SNA establishes a single discipline for all types of applications and eliminates the need for the duplication of facilities. Because of the uniformity of this architecture, host computer applications programmers will be able to ignore "handshake conventions" and communications procedures, because these will be handled by the system software.

Synchronous data link control (SDLC) is one part of SNA, specifically the line control discipline. The purpose of this discipline is to ensure the integrity of data transmitted over one data link (a telephone line, a satellite circuit, etc.). Information on the type of data being transmitted, its ultimate destination (it may have to travel over multiple data

[2]CRC Report No. 1275 "Data Terminal Standards and Protocols." Department of Communcations, Ottawa, Ontario, 1975, p. 51.

[3]"Everything You Always Wanted to Know About SNA." Nashua, N.H.: Sanders Data Systems, 1975.

links), the type of response expected from the addressee, and so on are handled by other parts of the SNA architecture.

Future Standardization

Standardization efforts will continue in all aspects of interactive terminal developments as they do in most technological areas. There are still many areas where standardization can benefit users, improve the capabilities of data communications networks to meet the requirements of remote data processing, and ensure the desired degree of compatibility among terminals and their host computers.

GLOSSARY

Access Method. A technique for moving data between main storage and an input/output device.

Address. A coded representation of the origin or destination of data. Multiple terminals on one communication line, for example, must have unique addresses. Telegraph messages reaching a switching center carry an address before their text to indicate the destination of the message.

Alphanumeric Field. A field that may contain any alphabetic, numeric, or special character.

Alphanumeric Keyboard. A typewriter-like keyboard used to enter letters, numbers, and special characters into a display station buffer; also used to perform special functions (such as backspacing) and to produce special control signals.

ANSI. American National Standards Institute.

Application Program. A program written by a user that applies to his own business requirements.

ASC. American Society for Communications.

ASCII. American Standard Code for Information Interchange. This is the code established as a standard for control characters and graphic characters; used for information interchange between data processing and communication systems and associated equipment.

Attention. An I/O interruption signal generated by a display station, usually as the result of an action taken by the operator of the device.

Attribute. A characteristic of a display field. The attributes of a display

field include: protected or unprotected; numeric only or alphanumeric input control; displayed, nondisplayed, display intensified; selector pen detectable or nondetectable; and modified or not modified.

Attribute Character. A code that defines the attributes of the display field that follows. An attribute character is the first character in a display field but is not a displayable character.

Baud. A unit of signaling speed. In an equal length code, one baud corresponds to a rate of one signal element per second.

Baudot Code. A code for the transmission of data in which five bits represent one character. It is named for Emile Baudot, a pioneer in printing telegraphy. The name is usually applied to the code used in many teleprinter systems and was first used by Murray, a contemporary of Baudot.

Bit Rate. The speed at which bits are transmitted, usually expressed in bits per second.

Buffer. The hardware portion of a display station, control unit, or buffered printer in which display or print data are stored.

Buffer Address. The address of a location in the buffer at which one character can be stored.

Byte. Generally, any separately manipulable group of bits within a binary fixed word. In most computers, a unit of information 8 bits in length which can represent a character (one out of 256) in EBCDIC.

Cathode Ray Tube (CRT). A television-like picture tube used in visual display terminals.

CCITT. Consultative Committee on International Telephone and Telegraph.

Channel Interface. The communication link between the channel unit and its attached control units, consisting of shared control and data lines.

Character. The actual or coded representation of a digit, letter, or special symbol.

Character Addressing. The process of gaining access to any character position in the buffer by using an address.

Character Generator. A hardware unit that converts the digital code for a character into signals that cause the cathode ray tube electron beam to create the character on the screen.

Character Position. A location on the screen at which one character can

be displayed; also, an addressed location in the buffer at which one character can be stored.

Clocking. Time base control signals within the terminal control unit, display station, or associated modems which regulate the bit rate of information transfer between a computer system and a remotely attached display system.

Code. A system of symbols and rules for use in representing information.

Command. An instruction that directs a control unit or device to perform an operation or a set of operations.

Communications Common Carrier. A company that offers its facilities to the public for universal communication services, and which is subject to public utility regulation.

Control Character. A character used in conjunction with a write command to specify that a control unit is to perform a particular operation.

Conversational Mode. A procedure for communication between a terminal and the computer in which each entry from the terminal elicits a response from the computer and vice versa.

Cursor. A unique symbol (often an underscore) that identifies a character position in a screen display; usually, the character position at which the next character entered from the keyboard will be displayed.

Data. Any representations such as characters or analog quantities to which meaning might be assigned.

Data Communications. The movement of encoded information by means of electrical transmission systems.

Data Entry Keyboard. A standard typewriter keyboard on which the numeric keys are grouped in a format similar to the numeric keys on a card punch keyboard (to facilitate entry of numeric data).

Data Set. A device that converts the signals of a business machine to signals that are suitable for transmission over communication lines and vice versa. It also may perform other related functions.

Data Stream. All data transmitted through a channel in a single read or write operation to display station or printer.

Detectable. An attribute of a display field which determines whether the field can be sensed by a light pen.

Dial Line. (*See* Switched Line.)

Display Field. A group of consecutive characters (in the buffer) that starts with an attribute character (defining the characteristics of the field) and contains one or more alphanumeric characters. The field continues to, but does not include, the next attribute character.

EBCDIC. Extended Binary Coded Decimal Interchange Code.

EIA. Electronics Industries Association (U.S.).

End of Message. A character in the data stream transmitted to a printer which marks the end of the data to be printed.

Even/Odd Parity Check. This is a check which tests whether the number of digits in a group of binary digits is even (even parity check) or odd (odd parity check).

Field. (*See* Display Field.)

Formatted Display. A screen display in which a display field (or fields) has been defined as a result of storing at least one attribute character in the display buffer.

Full Duplex. In communications, pertaining to a simultaneous two-way and independent transmission in both directions. Contrast with half-duplex.

Half-Duplex. Pertaining to an alternate, one-way-at-a-time, independent transmission. Contrast with full duplex.

Hard Copy. A printed copy of machine output in readable form, such as reports, listings, documents, or summaries.

Input. (a) The data to be processed; (b) The state or sequence of states occurring on a specified input channel; (c) The device or collective set of devices used for bringing data into another device; (d) A channel for impressing a state on a device or logic element; (e) The process of transferring data from an external storage to an internal storage.

Input Field. An unprotected field in which data can be entered, modified, or erased by any keyboard action.

Intensified Display. An attribute of a display field that causes data in that field to be displayed at a brighter level than other data displayed on the screen.

ISO. International Standards Organization.

Leased Line. (*See* Nonswitched Line.)

Message Switching. The switching technique of receiving a message,

storing it until the proper outgoing circuit and station are available, and then retransmitting it toward its destination.

New Line. A code sent to a printer which causes the printer to begin printing subsequent characters on a new line.

Nonswitched Line (*also called* Leased Line). A connection between a remote terminal and a computer that does not have to be established by dialing.

Null Character. An all-zero character that occupies a position in the storage buffer and is displayed as a blank.

Null Suppression. In reading the contents of the buffer for a display or printer, the bypassing of all null characters in order to reduce the amount of data to be transmitted or printed.

On-Line. Pertaining to equipment or devices in direct communication with the central processing unit. May be used also to describe terminal equipment connected to a transmission line.

Order Code. A code that may be included in the write data stream transmitted for a display station or printer; provides additional formatting or definition of the write data.

Parallel Transmission. The simultaneous transmission of a certain number of signal elements constituting the same data signal.

Polling. A technique by which terminals sharing a communication line are periodically interrogated to determine whether the terminals require service.

Protected Field. A display field for which the display operator cannot use the keyboard to enter, modify, or erase data.

Read-Modified Operation. An operation in which only those display fields that are operator-modified with null codes suppressed are transferred.

Real Time. (a) Pertaining to the actual time during which a physical process takes place; (b) Pertaining to the performance of a computation during a period, short in comparison with the actual time that the related physical process takes place so that results of the computation can be used in guiding the physical process.

Reperforator. Receiving perforator.

Serial Transmission. A method of information transfer in which the bits composing a character are sent sequentially. Contrast with parallel transmission.

Switched Line (*also called* Dial Line). A communication line in which the connection between the computer and a remote station is established by dialing.

Teleprinter. Term used to refer to the equipment used in a printing telegraph system. A teletypewriter.

Teleprocessing. A form of information handling in which a data processing system utilizes communication facilities.

Teletype. Trademark of the Teletype Corporation. Usually refers to a series of different types of teleprinter equipment such as transmitters, tape punches, reperforators, and page printers utilized for communication systems.

Teletypewriter. Term used to refer specifically to teleprint equipment.

Terminal. (a) A point at which information can enter or leave a communications network; (b) An input/output device designed to receive or send source data in an environment associated with the job to be performed and capable of transmitting entries to and obtaining output from the system of which it is a part.

Time-Sharing. A method of operation in which a computer facility is shared by several users for different purposes at (apparently) the same time. Although the computer actually services each user in sequence, the high speed of the computer makes it appear that the users all are handled simultaneously.

Unformatted Display. A screen display in which no attribute character (*and, there, no display field*) has been defined; the attributes of the displayed data are controlled by the hardware of the display device.

Unprotected Field. A display field for which the display station operator can use the keyboard to enter, modify, or erase data.

Wraparound. The continuation of an operation (for example, a read operation or a cursor movement operation) from the last character position in a buffer to the first character position in the buffer.

REFERENCES

1. Donald E. Murphy and Stephen A. Kallis, Jr. *Introduction to Data Communications.* Digital Equipment Corporation, Maynard, Mass., 1971.

2. *Introduction to 3270 Information Display System.* IBM Corporation, Data Processing Division, White Plains, New York, 1975.

BIBLIOGRAPHY

Baran, P. "Potential Market Demand for 2-Way Information Services." *Institute for the Future*, undated.

"Crisis in Data Communications—Some Projections of Growth." Reprinted from *Computer Decisions*, November, 1970.

"Data Communications." Auerbach Technology Evaluation Service, EDP Series, No. 9, Auerbach Info, Inc., Philadelphia, Pennsylvania, 1971.

Dunwell, S.W. "Computer Terminals." In *Telecommunication Research in the U.S. and Selected Foreign Countries*, Vol. II, National Aeronautical Establishment.

Gordon, Eugene I. and Lawrence Anderson. "New Display Technologies —An Editorial Viewpoint." *Proceedings of IEEE*, July, 1973.

Henle, R.A. "Interface Man-Machine Data Entry." In *Telecommunication Research in the U.S. and Selected Foreign Countries*, Vol. II, National Aeronautical Establishment.

Hobbs, "The Rationale for Smart Terminals." *IEEE Computer Magazine*, December, 1971.

Hopewell, "Trends in Data Communication." *Datamation*, August, 1973.

Jacobson, A.D. "Photoactivated Liquid Crystal Light Values." *Digital Technique Displays*, 1972 International Symposium on Information Displays.

Lekberg, Charles "The Tyranny of QWERTY." *Saturday Review Science*, September 30, 1972.

Martin, Andre. "Penetration Color Tubes Are Enhancing Information Displays." *Electronics*, February 14, 1973.

O'Neill, Hugh V. "Computers–Communications Networks." The Mitre Corporation, June, 1971.

SRI. "A Study of Trends in the Demand for Information Transfer." Prepared for NASA, 1971.

"Technological Forecast of Computer and Digital Communication Technology." Unpublished internal document for the Canadian Computer–Communications Task Force, January, 1972.

Weitzman, Carl. "Current and Future Graphic Displays for Military Systems." *Computer Design*, February 1973.

Yourdon, Edward. *Design of On-Line Systems*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

Zeidler, Lipinski, Moll, Shapiro, Kent, and Wensley. "Patterns of Technology in Data Processing and Data Communications." Report No. 73793-4, SRI, Menlo Park, 1969.

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boards, displays, memories, and printers. Practical application guidelines include typical examples for intelligent terminal applications. Emphasis is placed on user considerations in evaluating terminals and performance characteristics. Specification pages describe each terminal model in a standard format. Most interactive terminal models available to the market are represented.

Numerous photographs and tables illustrate different features of interactive terminals and performance. A bibliography of appropriate reference material is provided.

About the author:

Duane E. Sharp received his degree in engineering from Carleton University. He is President of Freelance Editorial and Marketing Services, Inc., and formerly was a lecturer in Business and Technical Communications at Ryerson Polytechnical Institute, Toronto, Ontario, Canada.

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Handbook of Interactive Computer Terminals

Duane E. Sharp

This comprehensive handbook clearly describes technologies of the various elements of interactive devices. It provides general and performance characteristics for 150 simple and intelligent terminals.

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